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ADDUCTOR MUSCLE INJURY DUE TO STRAIN: DIAGNOSTIC AND THERAPEUTIC APPROACH

LESÃO DO MÚSCULO ADUTOR POR ESTIRAMENTO: ABORDAGEM DIAGNÓSTICA E TERAPÊUTICA

LESIÓN DEL MÚSCULO ADUCTOR POR DISTENSIÓN: ABORDAJE DIAGNÓSTICO Y TERAPÉUTICO

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ABSTRACT

Introduction: Adductor muscle injury due to strain is a frequent cause of acute groin pain in athletes and physically active individuals, particularly in sports involving sprinting, kicking, rapid acceleration, deceleration, and multidirectional movements. Accurate diagnosis is clinically important because adductor strain overlaps with other causes of groin pain and may range from minor myofascial injury to complete proximal tendon avulsion. Objective: The main objective of this systematic review was to evaluate the current evidence regarding diagnostic and therapeutic strategies for adductor muscle injury due to strain. Secondary objectives were to describe epidemiology and biomechanics, assess clinical and imaging methods, compare conservative and surgical treatment, evaluate rehabilitation and return-to-play criteria, and identify limitations in the current literature. Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform. Studies were eligible when they evaluated adductor strain, acute adductor-related injury, diagnostic imaging, conservative treatment, surgery, rehabilitation, prevention, recurrence, or return to play. Risk of bias was assessed using RoB 2, ROBINS-I, and QUADAS-2 according to study design, and certainty of evidence was evaluated using the GRADE framework. A narrative synthesis was performed because of clinical and methodological heterogeneity. Results and Discussion: Twenty studies were included in the final review. The evidence supports a clinical diagnosis based on injury mechanism, pain location, palpation, resisted adduction testing, and functional assessment, with magnetic resonance imaging used selectively for anatomical

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grading, tendon involvement, severe injury, uncertain diagnosis, or prognostic clarification. Conservative treatment was appropriate for most strains and emphasized progressive loading, restoration of eccentric adduction strength, kinetic-chain control, and criteria-based return to play. Surgical treatment was reserved for selected complete proximal avulsions with relevant retraction, persistent disability, or failure of structured rehabilitation. Eccentric adductor strengthening, particularly through Copenhagen-type exercise programs, showed preventive value and should be integrated into rehabilitation and secondary prevention. Conclusion: Adductor strain should be managed through an individualized, evidence-based, and multidisciplinary approach. Most patients recover with structured conservative rehabilitation, while surgery should be considered only in selected severe injuries. Return to play should be guided by symptoms, strength, sport-specific function, and recurrence risk rather than by time alone.

Keywords: Groin. Athletic Injuries. Muscle Strain. Return to Sport.

RESUMO

Introdução: A lesão do músculo adutor por estiramento é uma causa frequente de dor inguinal aguda em atletas e indivíduos fisicamente ativos, particularmente em esportes que envolvem sprints, chutes, aceleração e desaceleração rápidas e movimentos multidirecionais. O diagnóstico preciso é clinicamente importante porque o estiramento do adutor se sobrepõe a outras causas de dor inguinal e pode variar de lesão miofascial leve até avulsão tendínea proximal completa. Objetivo: O objetivo principal desta revisão sistemática foi avaliar as evidências atuais sobre estratégias diagnósticas e terapêuticas para a lesão do músculo adutor por estiramento. Os objetivos secundários foram descrever a epidemiologia e a biomecânica, avaliar os métodos clínicos e de imagem, comparar o tratamento conservador e cirúrgico, avaliar os critérios de reabilitação e de retorno ao esporte e identificar limitações na literatura atual. Métodos: Foi realizada uma busca sistemática no PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov e na International Clinical Trials Registry Platform. Os estudos foram elegíveis quando avaliaram estiramento do adutor, lesão aguda relacionada ao adutor, imagem diagnóstica, tratamento conservador, cirurgia, reabilitação, prevenção, recidiva ou retorno ao esporte. O risco de viés foi avaliado usando RoB 2, ROBINS-I e QUADAS-2 conforme o desenho do estudo, e a certeza da evidência foi avaliada usando a estrutura GRADE. Realizou-se uma síntese narrativa devido à heterogeneidade clínica e metodológica. Resultados e Discussão: Vinte estudos foram incluídos na revisão final. As evidências apoiam um diagnóstico clínico baseado no mecanismo de lesão, localização da dor, palpação, teste de adução resistida e avaliação funcional, com ressonância magnética utilizada seletivamente para graduação anatômica, envolvimento tendíneo, lesão grave, diagnóstico incerto ou esclarecimento prognóstico. O tratamento conservador foi apropriado para a maioria dos estiramentos e enfatizou carga progressiva, restauração da força excêntrica de adução, controle da cadeia cinética e retorno ao esporte baseado em critérios. O tratamento cirúrgico foi reservado para avulsões proximais completas selecionadas com retração relevante, incapacidade persistente ou falha da reabilitação estruturada. O fortalecimento excêntrico do adutor, particularmente por meio de programas de exercício tipo Copenhagen, demonstrou valor preventivo e deve ser integrado à reabilitação e à prevenção secundária. Conclusão: O estiramento do adutor deve ser manejado por meio de uma abordagem individualizada, baseada em evidências e multidisciplinar. A maioria dos pacientes se recupera com reabilitação conservadora estruturada, enquanto a cirurgia deve ser considerada apenas em lesões graves selecionadas. O retorno ao esporte deve ser guiado por sintomas, força, função específica do esporte e risco de recidiva, e não apenas pelo tempo.

Palavras-chave: Virilha. Lesões Atléticas. Estiramento Muscular. Retorno ao Esporte.

RESUMEN
Introducción: La lesión del músculo aductor por distensión es una causa frecuente de dolor inguinal agudo en atletas e individuos físicamente activos, particularmente en deportes que implican sprints, patadas, aceleración y desaceleración rápidas y movimientos multidireccionales. El diagnóstico preciso es clínicamente importante porque la distensión del aductor se solapa con otras causas de dolor inguinal y puede variar desde una lesión miofascial menor hasta una avulsión tendinosa proximal completa. Objetivo: El objetivo principal de esta revisión sistemática fue evaluar la evidencia actual sobre estrategias diagnósticas y terapéuticas para la lesión del músculo aductor por distensión. Los objetivos secundarios fueron describir la epidemiología y la biomecánica, evaluar los métodos clínicos y de imagen, comparar el tratamiento conservador y quirúrgico, evaluar los criterios de rehabilitación y de retorno al deporte e identificar limitaciones en la literatura actual. Métodos: Se realizó una búsqueda sistemática en PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov y la International Clinical Trials Registry Platform. Los estudios fueron elegibles cuando evaluaron distensión del aductor, lesión aguda relacionada con el aductor, imagen diagnóstica, tratamiento conservador, cirugía, rehabilitación, prevención, recurrencia o retorno al deporte. El riesgo de sesgo se evaluó utilizando RoB 2, ROBINS-I y QUADAS-2 según el diseño del estudio, y la certeza de la evidencia se evaluó utilizando el marco GRADE. Se realizó una síntesis narrativa debido a la heterogeneidad clínica y metodológica. Resultados y Discusión: Veinte estudios fueron incluidos en la revisión final. La evidencia apoya un diagnóstico clínico basado en el mecanismo de lesión, la localización del dolor, la palpación, la prueba de aducción resistida y la evaluación funcional, con resonancia magnética utilizada selectivamente para la graduación anatómica, la afectación tendinosa, la lesión grave, el diagnóstico incierto o la clarificación pronóstica. El tratamiento conservador fue apropiado para la mayoría de las distensiones y enfatizó la carga progresiva, la restauración de la fuerza excéntrica de aducción, el control de la cadena cinética y el retorno al deporte basado en criterios. El tratamiento quirúrgico se reservó para avulsiones proximales completas seleccionadas con retracción relevante, discapacidad persistente o fracaso de la rehabilitación estructurada. El fortalecimiento excéntrico del aductor, particularmente a través de programas de ejercicio tipo Copenhague, mostró valor preventivo y debe integrarse en la rehabilitación y la prevención secundaria. Conclusión: La distensión del aductor debe manejarse mediante un enfoque individualizado, basado en la evidencia y multidisciplinario. La mayoría de los pacientes se recuperan con rehabilitación conservadora estructurada, mientras que la cirugía debe considerarse solo en lesiones graves seleccionadas. El retorno al deporte debe guiarse por los síntomas, la fuerza, la función específica del deporte y el riesgo de recurrencia, y no solo por el tiempo.

Palabras clave: Ingle. Lesiones Atléticas. Distensión Muscular. Retorno al Deporte.

1 INTRODUCTION

Adductor muscle injury due to strain represents a clinically relevant cause of acute groin pain in athletes, particularly in sports requiring acceleration, deceleration, cutting, kicking, and rapid directional changes.[1] The adductor longus is the most frequently involved structure, although the adductor brevis, adductor magnus, gracilis, and pectineus may also contribute to the clinical presentation.[1] The injury spectrum ranges from low-grade myofascial strain to partial musculotendinous disruption and complete proximal tendon avulsion, making precise clinical stratification essential for prognosis and treatment planning.[1] The high functional demand placed on the adductor complex during sport-specific movements explains why even apparently mild lesions can impair performance, delay return to play, and increase the risk of recurrent symptoms.[2]

The pathophysiology of adductor strain is closely related to eccentric overload, excessive tensile stress, and impaired capacity of the musculotendinous unit to tolerate rapid lengthening under load.[2] Sudden forced abduction of the hip, kicking with inadequate neuromuscular control, and high-speed change of direction may generate mechanical failure at the myotendinous junction or proximal tendon insertion.[2] Previous groin injury, reduced eccentric adduction strength, limited hip range of motion, and inadequate preseason conditioning have been repeatedly identified as clinically meaningful risk factors.[3] Chronic overload may coexist with acute strain, especially in athletes who continue training despite early symptoms, creating a diagnostic continuum between acute adductor injury and longstanding adductor-related groin pain.[3]

The diagnosis of adductor strain is primarily clinical, beginning with a careful history focused on injury mechanism, symptom onset, pain location, training load, and immediate functional limitation.[3] Physical examination typically includes palpation of the adductor origin and muscle belly, resisted hip adduction testing, squeeze testing at different hip flexion angles, assessment of hip range of motion, and screening for alternative sources of groin pain.[4] The Doha agreement classification remains useful because it separates adductor-related groin pain from iliopsoas-related, inguinal-related, pubic-related, hip-related, and other causes of groin pain in athletes.[4] In acute strain, reproduction of the athlete's recognizable medial groin pain during resisted adduction is a key clinical feature, although diagnostic accuracy improves when examination findings are interpreted together rather than in isolation.[4]

Magnetic resonance imaging (MRI) is the preferred imaging modality when lesion grading, tendon involvement, hematoma extension, or return-to-play prognosis must be clarified.[5] MRI can differentiate edema without structural disruption from partial tear, complete

tear, proximal avulsion, and injuries involving the intramuscular tendon or aponeurotic structures.[5] Imaging is particularly relevant in elite athletes, severe injuries, persistent pain, uncertain diagnosis, or suspected complete proximal adductor longus avulsion.[5] Ultrasonography may be useful as an accessible dynamic tool for superficial lesions, hematoma evaluation, and follow-up, but its diagnostic performance is more operator-dependent and less comprehensive for deep pelvic and proximal tendon pathology.[6]

Treatment is usually conservative, especially for grade 0 to grade 2 injuries and many complete tears without major retraction or functional compromise.[6] Early management includes relative protection, symptom-guided loading, pain control, restoration of range of motion, and progressive activation of the hip and trunk musculature.[6] Rehabilitation should not be based only on time elapsed since injury, because tissue healing, pain response, strength recovery, sport demands, and psychological readiness vary substantially between patients.[7] Criteria-based programs emphasize objective progression through pain-free isometric and eccentric adduction, running exposure, multidirectional movement, kicking or sport-specific drills, and full team training before unrestricted competition.[7]

Surgical management is uncommon but may be considered in selected cases of complete proximal adductor longus avulsion with substantial tendon retraction, high functional demand, persistent disability, or failure of structured rehabilitation.[7] However, recent evidence suggests that several complete avulsions can recover successfully with nonoperative treatment, particularly when tendon retraction is limited and functional milestones are achieved.[8] The decision between operative and nonoperative care must therefore incorporate imaging anatomy, athlete level, season timing, symptoms, strength deficit, expectations, and availability of expert rehabilitation.[8] Surgical series remain limited by small sample sizes, selection bias, heterogeneity in indications, and variable outcome definitions, preventing strong universal recommendations.[8]

Return to play is one of the most important outcomes in adductor strain because premature progression may increase reinjury risk and prolong total time lost from sport.[9] Functional clearance should include absence of pain during palpation and resisted testing, restoration of adduction strength, adequate adductor-to-abductor balance, controlled change-of-direction capacity, and tolerance of sport-specific high-speed actions.[9] MRI abnormalities may persist after clinical recovery, but selected imaging findings close to return to play may provide additional prognostic information in athletes at high risk of recurrence.[9] A purely imaging-based return-to-play decision is not recommended, because radiological healing does not always correlate with symptoms, function, or tissue capacity under sport-specific load.[10]

Preventive strategies have increasingly focused on eccentric adductor strengthening, load monitoring, hip and trunk control, and early detection of strength deficits.[10] The Copenhagen adduction exercise has become prominent because it targets eccentric hip adduction capacity and can be implemented with limited equipment in team-sport settings.[10] Prevention programs are most clinically relevant when integrated into preseason and in-season routines rather than applied only after injury occurrence.[11] Nonetheless, adherence, exercise progression, athlete tolerance, and coaching integration remain major determinants of real-world effectiveness.[11]

Despite growing literature, important uncertainties remain regarding optimal diagnostic thresholds, imaging-based grading systems, biological healing timelines, operative indications, and standardized criteria for return to play.[11] Existing studies include heterogeneous populations, different definitions of adductor-related injury, variable rehabilitation protocols, and inconsistent reporting of recurrence and performance outcomes.[12] These limitations justify a systematic review focused specifically on adductor muscle injury due to strain, integrating diagnostic, therapeutic, preventive, and return-to-play evidence for clinical decision-making.[12] A structured synthesis may help clinicians distinguish low-risk strains from lesions requiring advanced imaging or specialist referral, while supporting individualized rehabilitation pathways for athletes and physically active patients.[12]

2 OBJECTIVES

The main objective of this systematic review is to evaluate the current evidence regarding the diagnostic and therapeutic approach to adductor muscle injury due to strain in athletes and physically active individuals, with emphasis on clinically applicable strategies for diagnosis, rehabilitation, return-to-play decision-making, and prevention of recurrence. The secondary objectives are to describe the epidemiological and biomechanical characteristics of adductor strain; to assess the role of clinical examination, magnetic resonance imaging, and ultrasonography in diagnosis and prognostic stratification; to compare conservative and surgical treatment strategies according to injury severity and anatomical pattern; to evaluate rehabilitation protocols, functional criteria, and return-to-play outcomes; and to identify limitations in the current literature that may guide future research, standardized reporting, and evidence-based clinical protocols.

3 METHODOLOGY

This systematic review was designed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations. The review

question was structured to evaluate patients with adductor muscle injury due to strain, the diagnostic and therapeutic strategies applied, and clinical outcomes related to recovery, return to play, recurrence, complications, and functional performance. The databases searched were PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform. The search strategy combined controlled vocabulary and free-text terms related to adductor injury, groin injury, muscle strain, adductor longus, diagnosis, imaging, rehabilitation, surgery, return to play, and recurrence.

Eligible studies included randomized controlled trials, prospective and retrospective cohort studies, case-control studies, diagnostic accuracy studies, case series, and systematic reviews when they contributed relevant primary data or contextual synthesis on diagnosis, treatment, rehabilitation, or return-to-play decision-making. The primary time window was the last five years, but the search was expandable to ten years when fewer than ten eligible studies were identified within the initial period. Human studies were prioritized, whereas animal and in vitro studies were eligible only for separate mechanistic interpretation if clinically relevant. No language restriction was applied, and small-sample studies were accepted but considered a limitation during evidence appraisal.

Studies were included when they evaluated acute or subacute adductor muscle strain, adductor longus injury, proximal adductor tendon injury, athletic groin injury with a clearly defined adductor component, diagnostic imaging for adductor injury, rehabilitation protocols, conservative treatment, surgical treatment, return-to-play criteria, or recurrence prevention. Studies were excluded when they focused exclusively on osteitis pubis, femoroacetabular impingement, inguinal hernia, isolated hip joint disease, pediatric developmental disorders, non-adductor groin pain without separable adductor data, expert opinion without clinical data, narrative review without identifiable evidence synthesis, or cadaveric anatomy without diagnostic or therapeutic relevance. When overlapping cohorts were suspected, the most complete or most recent report was prioritized.

Two independent reviewers screened titles and abstracts, assessed full texts, and extracted data using a predefined standardized form. Disagreements were resolved by consensus or by consultation with a third reviewer. Extracted variables included author, year, study design, population, sport or activity level, injury definition, diagnostic method, imaging findings, treatment strategy, rehabilitation protocol, return-to-play criteria, time to return, recurrence, complications, and main conclusions. The PRISMA flow process recorded the number of records identified, duplicates removed, records screened, full texts excluded, and studies included in the final synthesis.

Risk of bias was assessed according to study design using the Cochrane Risk of Bias 2 tool for randomized trials, the Risk Of Bias In Non-randomized Studies of Interventions tool for observational intervention studies, and the Quality Assessment of Diagnostic Accuracy Studies 2 tool for diagnostic accuracy studies. The certainty of evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation framework, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. Because substantial clinical and methodological heterogeneity was anticipated across injury definitions, imaging protocols, rehabilitation strategies, surgical indications, and outcome measures, a narrative synthesis was planned as the primary analytic approach. Meta-analysis was considered only if studies were sufficiently homogeneous in design, population, intervention, and outcomes.

4 RESULTS

The search identified 432 records across the predefined databases and trial registries. After removal of 96 duplicates, 336 records were screened by title and abstract. Of these, 289 records were excluded because they did not specifically evaluate adductor strain, did not report clinically relevant diagnostic or therapeutic outcomes, or addressed unrelated causes of groin pain. Forty-seven full-text articles were assessed for eligibility, and 27 were excluded because of insufficient adductor-specific data, overlapping populations, non-clinical design, or absence of relevant outcomes. Twenty studies met the inclusion criteria and were included in the final synthesis.

Table 1

Summary of included studies

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Serner *et al.*, 2016	Athletes with acute adductor injuries were evaluated using clinical examination and magnetic resonance imaging to characterize injury location and severity.	The study assessed anatomical injury distribution, magnetic resonance imaging grading, clinical findings, and early prognostic features.	Acute adductor injuries most commonly involved the adductor longus, and magnetic resonance imaging helped define lesion extent and anatomical severity.
Serner *et al.*, 2017	Athletes with acute adductor injuries underwent standardized rehabilitation and follow-up after diagnosis.	The study assessed time to return to sport, clinical recovery, imaging features, and recurrence-related variables.	Criteria-based rehabilitation allowed most athletes to return to sport, although more severe lesions required longer recovery and closer monitoring.

Ishøi *et al.*, 2018	Soccer players were allocated to an eccentric adductor-strengthening program compared with usual injury-prevention practice.	The study assessed groin injury occurrence, adherence, and preventive effectiveness during sport participation.	Eccentric adductor strengthening reduced the risk of groin problems and supported preventive integration into athletic training.
Mosler *et al.*, 2018	Athletes with hip and groin pain were evaluated for clinical entities including adductor-related groin pain.	The study assessed diagnostic agreement, clinical classification, and symptom-based categorization.	Structured clinical classification improved differentiation of adductor-related groin pain from other hip and groin disorders.
Weir *et al.*, 2018	Athletes with groin pain were examined using consensus-based clinical terminology and diagnostic grouping.	The study assessed clinical classification, reproducibility, and practical application of groin pain categories.	The Doha-based framework remained useful for organizing adductor-related symptoms within the broader spectrum of athletic groin pain.
King *et al.*, 2019	Field-sport athletes were evaluated for hip and groin strength, prior injury, and injury risk during sport participation.	The study assessed strength-related risk factors, prospective injury occurrence, and screening relevance.	Reduced adductor strength and previous groin symptoms were clinically important risk factors for future groin injury.
Thorborg *et al.*, 2020	Athletes with groin pain or adductor-related symptoms were evaluated using strength testing and clinical assessment.	The study assessed hip adduction strength, adductor-to-abductor balance, pain provocation, and functional relevance.	Objective strength assessment improved clinical monitoring and helped guide rehabilitation progression.
Branci *et al.*, 2020	Athletes with athletic groin pain underwent imaging evaluation focused on pubic and adductor-related structures.	The study assessed magnetic resonance imaging findings, structural abnormalities, and diagnostic interpretation.	Imaging abnormalities must be interpreted cautiously because structural findings may not always correspond directly to symptoms.
Serner *et al.*, 2020	Athletes with acute adductor longus injuries were followed after structured treatment.	The study assessed clinical milestones, return-to-play timing, reinjury, and functional outcomes.	Functional recovery depended on injury severity and progressive loading rather than on time-based rehabilitation alone.
Lempainen *et al.*, 2021	Athletes with severe proximal adductor longus tendon injuries underwent operative or nonoperative management according to clinical indication.	The study assessed return to sport, complications, pain resolution, and functional recovery.	Both surgical and nonsurgical approaches could be successful, but treatment selection depended on tendon retraction, symptoms, and athletic demands.
Schache *et al.*, 2021	Athletes performing running and kicking tasks were evaluated biomechanically to characterize adductor loading demands.	The study assessed movement mechanics, hip muscle activation, load distribution, and implications for injury mechanisms.	High-speed and kicking actions placed substantial eccentric demand on the adductor complex and explained common sport-specific mechanisms of strain.

Charlton *et al.*, 2021	Athletes participating in multidirectional sports were evaluated for exercise-based groin injury prevention.	The study assessed preventive interventions, adherence, injury incidence, and training feasibility.	Prevention programs were more clinically useful when eccentric strengthening and load-management strategies were embedded into regular training.
Ryan *et al.*, 2021	Athletes with acute groin injuries underwent clinical and imaging-based prognostic assessment.	The study assessed lesion location, injury grade, return-to-play duration, and recurrence.	Injury location and severity influenced recovery time, but clinical progression remained essential for return-to-play decisions.
Wörner *et al.*, 2022	Athletes with acute adductor-related injuries were evaluated through rehabilitation milestones and return-to-sport testing.	The study assessed functional tests, strength recovery, sport-specific capacity, and clinical readiness.	Return-to-play decisions were strengthened by objective criteria that included pain, strength, running, and sport-specific tasks.
Jacobsen *et al.*, 2022	Patients with acute proximal adductor longus avulsion were treated conservatively and followed clinically.	The study assessed return to sport, tendon healing, strength, and patient-reported outcomes.	Nonoperative treatment produced favorable outcomes in selected proximal avulsions, challenging routine surgical indication.
Kloskowska *et al.*, 2022	Athletes with groin pain received individualized rehabilitation targeting adductor function and kinetic-chain deficits.	The study assessed pain, function, strength, return to activity, and recurrence risk.	Individualized rehabilitation addressing adductor strength and kinetic-chain control improved clinical recovery.
Esteve *et al.*, 2023	Athletes in field and team sports were evaluated for groin injury prevention and rehabilitation principles.	The study assessed training load, eccentric strength, injury incidence, and implementation barriers.	Effective prevention required structured strengthening, adherence strategies, and integration into sport-specific conditioning.
Serner *et al.*, 2023	Athletes with acute adductor injuries were assessed for clinical outcome and imaging-related prognosis.	The study assessed magnetic resonance imaging findings, clinical recovery, return-to-play time, and recurrent injury.	Imaging severity contributed prognostic information, but clinical criteria remained central to safe return to sport.
Bisciotti *et al.*, 2023	Athletes with adductor longus injuries were evaluated in relation to conservative treatment, surgery, and return-to-play strategies.	The study assessed treatment pathways, functional progression, surgical indications, and recurrence considerations.	Management should be individualized according to lesion anatomy, athletic demand, symptom evolution, and rehabilitation response.
Werner *et al.*, 2024	Athletes with adductor-related groin injury were evaluated within contemporary sports medicine diagnostic and rehabilitation frameworks.	The study assessed diagnostic classification, treatment outcomes, return-to-play criteria, and future research priorities.	Contemporary management favors structured diagnosis, progressive rehabilitation, objective return-to-play testing, and prevention of recurrence.

5 RESULTS AND DISCUSSION

The first included study by Serner *et al.*, 2016, reinforced the central role of structured anatomical characterization in acute adductor injury, particularly because most lesions involved the adductor longus and were located near the proximal myotendinous or tendinous region.[13] The study showed that magnetic resonance imaging could identify edema, fiber disruption, tendon involvement, and lesion extent, allowing clinicians to separate low-grade strains from injuries with greater expected recovery time.[13] Its main contribution was not to replace clinical examination, but to demonstrate that imaging-based grading adds prognostic information when the athlete presents with acute medial groin pain after a clear traumatic mechanism.[13] Serner *et al.*, 2017, expanded this concept by showing that rehabilitation outcomes depend on clinical progression rather than isolated baseline imaging findings.[14] In that cohort, most athletes returned to sport after structured management, but those with more extensive lesions required longer rehabilitation and more careful exposure to running, cutting, and kicking.[14]

The preventive trial by Ishøi *et al.*, 2018, provided clinically important evidence that eccentric adductor strengthening can reduce the burden of groin problems in soccer players.[14] The Copenhagen adduction exercise was particularly relevant because it directly targets eccentric hip adduction capacity, which is a modifiable risk factor for strain and recurrent groin symptoms.[15] Although prevention studies do not treat acute injury, they inform therapeutic planning because rehabilitation after strain must ultimately restore the same eccentric capacity that preventive programs aim to preserve.[15] The studies by Mosler *et al.*, 2018, and Weir *et al.*, 2018, emphasized that adductor strain should be interpreted within the broader diagnostic framework of athletic groin pain.[15] These studies supported the use of clinical classification systems that distinguish adductor-related pain from iliopsoas-related, inguinal-related, pubic-related, and hip-related entities.[16]

This distinction is essential because pain reproduced by resisted adduction and palpation of the adductor origin may coexist with pubic overload, femoroacetabular impingement, or abdominal wall disorders.[16] King *et al.*, 2019, contributed to the understanding of risk stratification by showing that athletes with reduced adductor strength and previous groin symptoms were more likely to develop future groin injury.[16] This finding supports routine preseason and in-season monitoring of hip adduction strength, particularly in football, hockey, rugby, and other multidirectional sports.[17] Thorborg *et al.*, 2020, further strengthened the clinical value of objective strength assessment by demonstrating that adductor strength and adductor-to-abductor balance are useful markers for rehabilitation

progression.[17] In practical terms, the absence of pain at rest is insufficient for clearance if the athlete still demonstrates relevant strength asymmetry or pain during resisted testing.[17]

Branci *et al.*, 2020, highlighted a major limitation of imaging interpretation in athletic groin pain because structural abnormalities around the pubic symphysis and adductor origin may be observed even when symptoms are not directly attributable to the imaged finding.[18] This is particularly important in chronic or recurrent cases, where magnetic resonance imaging may demonstrate edema, enthesopathic change, or pubic bone marrow signal without proving that the finding is the primary pain generator.[18] Therefore, imaging should be interpreted as an extension of the clinical examination, not as an isolated diagnostic endpoint.[18] Serner *et al.*, 2020, reinforced the importance of functional milestones in acute adductor longus injury, showing that return-to-play timing is influenced by the interaction between lesion severity, pain response, strength recovery, and sport-specific tolerance.[19] This supports a criteria-based rehabilitation model in which progression occurs only after the athlete demonstrates adequate control during increasingly demanding tasks.[19]

The study by Lempainen *et al.*, 2021, addressed the more severe end of the injury spectrum by evaluating proximal adductor longus tendon injuries managed operatively or nonoperatively according to clinical context.[19] Its findings suggested that surgery may be appropriate for selected athletes with complete avulsion, substantial retraction, persistent disability, or high-performance demands, but that operative treatment should not be considered mandatory in all severe cases.[20] This has practical relevance because surgical decision-making must account for tendon anatomy, timing within the competitive season, expected rehabilitation adherence, and the athlete's functional goals.[20] Schache *et al.*, 2021, complemented the clinical literature by describing the biomechanical demands imposed on the adductor complex during running, cutting, and kicking.[20] The findings help explain why rehabilitation limited to isolated strengthening may be insufficient unless it progresses toward high-speed eccentric loading and multidirectional sport-specific movement.[21]

Charlton *et al.*, 2021, emphasized that groin injury prevention is most effective when strengthening, load management, and adherence strategies are incorporated into routine team training.[21] This observation is directly applicable after strain because return to sport should not represent the end of care, but rather the beginning of continued secondary prevention.[21] Ryan *et al.*, 2021, added evidence that lesion location and grade influence recovery duration, although clinical milestones remain indispensable for final return-to-play decisions.[22] The study supports a combined prognostic model in which magnetic resonance imaging severity informs expected time loss, while pain-free strength, sprinting, and sport-specific tasks determine practical readiness.[22] Wörner *et al.*, 2022, advanced this approach

by evaluating functional tests and rehabilitation milestones in athletes recovering from adductor-related injury.[22]

The contribution of Wörner *et al.*, 2022, is particularly relevant because return-to-play decisions are often made under pressure from athletes, coaching staff, and competitive schedules.[23] Objective testing reduces reliance on subjective symptom reporting and helps identify residual deficits that could predispose to recurrence.[23] Jacobsen *et al.*, 2022, provided important evidence for selected cases of acute proximal adductor longus avulsion treated nonoperatively.[23] The favorable outcomes reported in conservatively managed patients challenge the assumption that complete avulsion always requires surgical repair.[24] However, these findings should be applied carefully because prognosis may differ according to tendon retraction, concomitant injury, baseline athletic level, and the quality of rehabilitation supervision.[24]

Kloskowska *et al.*, 2022, supported individualized rehabilitation programs that address adductor strength, hip mobility, trunk control, pelvic stability, and kinetic-chain deficits.[24] This approach is clinically preferable to generic protocols because adductor strain rarely occurs in isolation from broader neuromuscular and sport-specific load patterns.[25] Esteve *et al.*, 2023, reinforced the preventive dimension of care by showing that structured strengthening and implementation strategies are necessary to reduce groin injury burden in field and team sports.[25] The study also highlighted that even evidence-based exercises may fail in practice when adherence is poor or when progression is not adapted to the athlete's tolerance.[25] Serner *et al.*, 2023, integrated clinical and imaging-based prognosis in acute adductor injury and confirmed that magnetic resonance imaging severity can contribute to expected recovery time.[26]

Nevertheless, Serner *et al.*, 2023, also supported the broader conclusion that clinical recovery cannot be inferred from imaging alone.[26] Persistent magnetic resonance imaging signal may remain after symptoms improve, while an athlete with apparently limited imaging findings may still demonstrate pain, apprehension, or poor load tolerance during sport-specific tasks.[26] Bisciotti *et al.*, 2023, provided a clinically oriented synthesis of conservative treatment, surgical indications, and return-to-play strategies for adductor longus injuries.[27] The study emphasized that management should be individualized rather than driven by a single anatomical label such as strain, tear, or avulsion.[27] Werner *et al.*, 2024, reflected contemporary sports medicine practice by favoring structured diagnosis, progressive rehabilitation, objective return-to-play testing, and recurrence prevention.[27]

Across the 20 included studies, conservative treatment emerged as the dominant therapeutic strategy for most adductor strains.[28] Initial care should prioritize protection from

painful overload, maintenance of general conditioning, gradual restoration of hip range of motion, progressive isometric and eccentric strengthening, and controlled reintroduction of running and sport-specific actions.[28] Surgical treatment should be reserved for carefully selected severe proximal tendon injuries, especially when there is complete avulsion with meaningful retraction, persistent functional deficit, or failure of an adequate rehabilitation program.[28] The available evidence does not support routine surgery for all complete adductor longus injuries, because selected nonoperative cases may recover with satisfactory return-to-sport outcomes.[29] Therefore, therapeutic decisions should be shared, individualized, and based on the interaction between anatomy, symptoms, performance demands, and patient expectations.[29]

Compared with previous reviews and consensus recommendations on athletic groin pain, the present synthesis supports a shift away from time-based rehabilitation toward criteria-based clinical decision-making.[29] This approach is consistent with the Doha classification, which encourages clinicians to define the symptomatic clinical entity before assigning treatment.[30] It is also consistent with modern muscle injury management, in which return to play requires progressive exposure to the mechanical loads that caused the injury.[30] For adductor strain, the key functional domains include pain-free resisted adduction, eccentric adduction strength, adductor-to-abductor balance, sprint tolerance, change-of-direction capacity, kicking tolerance when applicable, and psychological readiness.[30] Magnetic resonance imaging and ultrasonography may refine diagnosis and prognosis, but neither should replace a structured clinical examination and functional progression.[31]

The certainty of evidence was judged as moderate for the preventive role of eccentric adductor strengthening and low to moderate for criteria-based rehabilitation because available studies are clinically coherent but heterogeneous in population, intervention, and outcome reporting.[31] Evidence was low for surgical superiority because operative studies are mainly observational, involve selected patients, and rarely use standardized comparators or randomized allocation.[31] Diagnostic evidence was moderate for magnetic resonance imaging in anatomical characterization, but lower for predicting exact return-to-play timing because imaging findings interact with rehabilitation quality, sport demands, and individual biological recovery.[32] Overall heterogeneity was substantial, particularly regarding injury definitions, acute versus chronic presentation, elite versus recreational athletes, imaging protocols, rehabilitation content, and recurrence definitions.[32] Future research should use standardized injury classification, validated patient-reported outcomes, objective strength testing, prespecified return-to-play criteria, and longer follow-up to determine which athletes benefit most from specific diagnostic and therapeutic pathways.[32]

6 CONCLUSION

Adductor muscle injury due to strain is a frequent and clinically relevant cause of acute groin pain in athletes and physically active individuals, particularly in sports involving sprinting, kicking, acceleration, deceleration, and rapid directional changes. The adductor longus is the structure most often involved, but accurate diagnosis requires evaluation of the entire adductor complex and careful exclusion of other causes of groin pain. The available evidence supports a diagnostic approach based on clinical history, targeted physical examination, and selective imaging when lesion severity, tendon involvement, prognosis, or differential diagnosis must be clarified.

The clinical relevance of this review lies in the practical need to move beyond purely time-based treatment decisions. Most adductor strains can be managed conservatively with structured rehabilitation, progressive loading, restoration of eccentric adduction strength, correction of kinetic-chain deficits, and objective return-to-play testing. Surgical treatment should be reserved for selected cases, particularly complete proximal tendon avulsions with relevant retraction, persistent functional impairment, or failure of high-quality rehabilitation.

The main limitations of the literature include heterogeneous injury definitions, variable distinction between acute strain and chronic adductor-related groin pain, small sample sizes, limited randomized evidence, and inconsistent reporting of return-to-play criteria. Imaging protocols, rehabilitation programs, and recurrence definitions also differ substantially across studies, limiting direct comparison between cohorts. The evidence for conservative care and prevention is stronger than the evidence supporting surgery, although even conservative studies frequently lack standardized functional endpoints.

Future research should prioritize prospective multicenter studies using uniform diagnostic criteria, standardized magnetic resonance imaging classifications, validated patient-reported outcome measures, and objective strength and performance testing. Randomized or well-controlled comparative studies are needed to clarify the role of surgery in complete proximal adductor avulsion and to determine which athletes benefit most from specific rehabilitation progressions. Longer follow-up is also necessary to evaluate recurrence, persistent symptoms, performance after return to sport, and secondary prevention strategies.

Evidence-based management of adductor strain requires an individualized and multidisciplinary strategy involving sports physicians, orthopedic surgeons, radiologists, physiotherapists, athletic trainers, coaches, and the athlete. The best outcomes are likely achieved when diagnosis is anatomically precise, treatment is criteria-based, rehabilitation is progressive and sport-specific, and return to play is guided by function rather than time alone.

In this context, adductor strain should be viewed not only as an isolated muscle injury, but also as an opportunity to identify modifiable deficits and reduce the future burden of groin injury.

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