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Review

The influence of Copenhagen adduction exercise on the management of groin pain: A systematic review

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ABSTRACT

Groin injuries are common in sports like soccer, and low eccentric hip adduction strength is a major risk factor. The Copenhagen Adduction Exercise (CAE) is a high-intensity exercise designed to strengthen the hip adductors and reduce injury risk. This systematic review examined the effects of CAE on groin pain management in male athletes and active individuals. A literature search across four databases identified ten randomized controlled trials with 1,099 participants. The CAE consistently improved eccentric hip adduction strength, hip range of motion, dynamic balance, and reduced groin-related symptoms. Its effectiveness depends on adequate training volume and progressive overload, with higher volumes yielding better outcomes. Despite some variability among studies, the overall evidence supports CAE as a preventive and rehabilitative tool. It is simple, field-friendly, and suitable for inclusion in warm-up routines or strength programs. Coaches and clinicians are encouraged to apply individualized, progressive protocols, particularly in team sports like soccer and hockey.

Introduction

Muscle injuries are highly prevalent in sports such as soccer, basketball, hockey, and athletics, accounting for more than 40% of total injuries in some disciplines .[1] Groin pain accounts for up to 10% of sports injury clinic visits with a higher prevalence in males aged 26–30 .[2,3] In soccer specifically, adductor-related groin injuries represent 64–69% of all groin injuries[4,5] and are the second most common muscle injury among soccer players .[1] These injuries result in an average absence of 15 days, and up to 40% of affected players miss more than 28 days of competition .[5] The most common injury mechanisms in soccer involve kicking and changes of direction, which impose high eccentric demands on the adductor muscles .[4]

Several studies have identified low eccentric hip adduction strength (EHAD) as an intrinsic risk factor for groin pain, especially in soccer players with a history of injury .[4,6] As a result, prevention and rehabilitation programs have incorporated adductor strengthening exercises to reduce injury incidence and time loss .[1] However, commonly used protocols such as the FIFA 11+ lack specific exercises targeting hip adduction strength, which may limit their effectiveness in preventing groin injuries .[6] In this context, the Copenhagen Adduction Exercise (CAE) has gained attention for its ability to improve EHAD and reduce the risk of adductor-related injuries .[4]

The CAE is a dynamic, high-intensity partner exercise that requires no equipment and can be easily performed on the field or in any training facility .[1,6] The CAE is usually performed by side-lying on the floor with the upper leg supported in the air by a teammate or a bench. The hip is adducted until the body forms a straight line from the ankles to the shoulders (concentric phase). Then the player is instructed to lower the body slowly (eccentric phase) until reaching the floor to start the next repetition .[7] EMG studies have shown that the CAE produces very high levels of activation, reaching 108% of maximal voluntary isometric contraction in the adductor longus of the dominant leg .[4]

Scientific studies have demonstrated significant improvements following CAE interventions. For instance, Ishøi et al.[5] reported a 35.7% increase in EHAD after an 8-week program, and Harøy et al.[6] observed a 36% increase in U19 sub-elite soccer players. A recent systematic review and meta-analysis confirmed a significant effect size in favor of the CAE (mean difference = 0.61 Nm/kg; p = 0.003) .[1] However, Dawkins et al.[4] found that low-dose interventions (e.g., twice weekly for six weeks) did not significantly improve EHAD, although they increased peak adductor squeeze strength. Moreover, most studies have focused on young male

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athletes, limiting the generalizability of the results to other populations.

Given this background, the aim of the present systematic review was to evaluate the influence of the CAE on groin pain management in athletes and physically active individuals. By synthesizing the available literature, this review seeks to offer practical recommendations on CAE implementation, optimal training parameters, and expected benefits in prevention and rehabilitation programs. Considering the high prevalence of groin injuries and the simplicity of the CAE, the results may serve as a valuable guide for coaches, clinicians, and sports professionals aiming to apply evidence-based strategies in real-world training settings.

Materials and methods

Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines .[8] The PRISMA checklist guided the design, conduct, and reporting of the review, ensuring adherence to recognized standards for high-quality systematic reviews. The protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration number: CRD420251020202).

Literature search strategies

A systematic search was conducted across four electronic databases: Web of Science (WoS), PubMed, Scopus, and SportDiscus, from their inception dates up to March 10, 2025. The search was limited to studies published in English; articles in other languages were excluded.

The strategy was based on the use of keywords connected by Boolean operators and applied consistently across all four databases. Medical Subject Headings (MeSH) were used to refine the queries, combining terms such as “Copenhagen Adduction Exercise” [Title] The specific search strategies used in each database are detailed in Table 1.

Eligibility criteria

The research question guiding this systematic review was: “How does the CAE influence the prevention and management of groin pain in athletes and physically active individuals?” To structure the eligibility criteria, the PICOS framework was applied.

- **Population**: Athletes (e.g., soccer and hockey players) and physically active individuals
- **Intervention**: Copenhagen Adduction Exercise programs
- **Comparation**: Individuals without a specific intervention or receiving an alternative program
- **Outcomes**: Improvements in groin-related variables (e.g., strength, symptoms, function)
- **Study design**: Randomized Controlled Trials

Study selection

To streamline and organize the selection process, Mendeley reference management software was used to manage citations and systematically track inclusion decisions. Two reviewers independently screened all records retrieved from the four databases based on titles and abstracts. Studies that did not align with the objectives of the review were excluded.

Subsequently, the same two reviewers conducted a comprehensive full-text analysis of the remaining articles to determine their eligibility. During both the initial screening (title and abstract) and the full-text review phases, a third reviewer was consulted to resolve any discrepancies and reach consensus.

In addition to the database search, the reference lists of the included studies and relevant reviews were manually screened to identify additional eligible studies.

Finally, studies that exclusively reported results using magnitude-based inference without traditional statistical testing were excluded.

Table 1
Data bases search strategy.

Data bases	Search strategy	Identified records
Web Of Science	“Copenhagen Adduction Exercise” (Title)	n = 16
PubMed	“Copenhagen Adduction Exercise” .[Title]	n = 13
Scopus	TITLE (“Copenhagen adduction exercise”)	n = 16
SportDiscus	TI “Copenhagen adduction exercise”	n = 9

Data Extraction

Data extraction was conducted independently by two authors using Microsoft Excel (Microsoft Corp. Redmond, WA, USA) to organize the information for further analysis and synthesis, ensuring a systematic and transparent approach. Any discrepancies were resolved through discussion, and if necessary, a third reviewer was consulted to reach consensus.

The extracted data from each study included in the systematic review comprised the following aspects:

- Study characteristics
  - Authors
  - Year of publication
  - Study Design
- Population information
  - Number of participants
  - Gender
  - Age
  - Practiced sport
- Outcome measures and measures instruments
- CAE interventions ́ parameters

To ensure consistency and accuracy, references were managed using Mendeley reference management software. Additionally, when necessary, missing or unclear information was clarified by contacting the corresponding authors of the included studies. Detailed data from each study are presented in Tables 4-6.

Risk of bias assessment using PEDro scale

The risk of bias assessment for this systematic review was assessed using the Physiotherapy Evidence Database (PEDro) scale, a widely recognized tool for evaluating the internal validity and methodological rigor of randomized controlled trials (RCTs). The PEDro scale consists of 11 items (Table 2), each assessing the critical aspects of trial design and execution. The first item was not included in the final score, and each remaining item was rated as “yes” (1 point) or “no” (0 points), resulting in a maximum possible score of 10 points.

The quality assessment and risk of bias was conducted independently by two reviewers. A third reviewer was consulted to reach a consensus and resolve any discrepancies. For this review, a score of 6 or higher was considered indicative of moderate to good quality.

Risk of bias assessment using Cochrane scale

Also, two reviewers independently assessed the methodological quality of the articles included using the ROB 2.0 tool, which consists of five domains and overall criterion. The five domains are: (a) bias arising from the randomization process, (b) bias due to deviations from intended interventions, (c) bias due to missing outcome data, (d) bias in

Table 2
Item scores and final PEDro scale rating for studies included in the systematic review.

Study	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	PT
Quintana-Cepedal et al.[7]	1	1	0	1	0	0	1	0	0	1	1	5/10
Pippas et al.[11]	1	1	1	1	0	0	1	1	1	1	1	8/10
Alsirhani et al.[12]	1	1	1	1	1	0	1	1	1	1	1	9/10
Fujisaki et al.[13]	0	1	1	0	0	0	0	1	1	1	1	6/10
Alonso-Fernández et al.[14]	0	1	0	1	0	0	1	1	1	1	1	7/10
Alonso-Calvete et al.[15]	0	1	0	1	0	0	0	1	1	1	1	6/10
Dawkins et al.[4]	1	1	1	1	0	0	1	1	1	1	1	8/10
Attar et al.[16]	0	1	1	1	0	0	0	1	0	1	1	6/10
Harøy et al.[17]	1	1	1	1	0	0	0	0	1	1	1	6/10
Ishøi et al.[5]	1	1	1	1	0	1	0	0	0	1	1	6/10

P1. Eligibility criteria; P2. Random allocation; P3. Concealed allocation; P4. Similar groups at baseline; P5. Blinding of subjects; P6. Blinding of therapists; P7. Blinding of assessors; P8. Adequate follow-up; P9. Intention-to-treat analysis; P10. Between-group comparisons; P11. Point measures and variability; and PT. Total PEDro Scale score

measurement of the outcome, and (e) bias in reporting results .[9] (see Table 3).

Results

Literature search and study selection

The search and screening process is summarized in a flowchart as shown in Fig. 1, which details the number of records identified, screened, and included at each stage.

Initially, a total of 54 records were identified from four databases: WoS (n = 16), PubMed (n = 13), Scopus (n = 16), and SportDiscus (n = 9) which were reduced to 18 when the duplicates were eliminated (n = 36).

Then, eighteen titles and abstracts were examined, and all eighteen full-text articles were considered potentially relevant. However, ten studies were excluded for not meeting the eligibility criteria: one study did not publish the full-text article, one study did not written in English, six studies were not randomized controlled trials, one study combined the CAE with other exercise in all intervention groups and one study was a review. Ultimately, eight studies met the inclusion criteria and were included in the systematic review. In addition, two records identified through citation searching were also included

In total, ten studies were finally included in this systematic review. The study selection process is outlined in Fig. 1.

Risk of bias assessment using PEDro scale

The risk of bias assessment for this systematic review was assessed using the PEDro scale. Table 2 detailing the evaluation criteria applied to each study, including aspects such as randomization, blinding of participants and assessors, data integrity and risk of bias in the reporting of results. This information enables an appraisal of each study's internal validity and the degree of reliability they contribute to the evidence synthesis.

The results of the methodological quality assessment (Table 2) showed that most studies achieved an average score of 6 to 7 points. This moderate score reflected the inherent challenges of blinding participants, therapists and assessors to the measured variables. Nevertheless, the studies met most of the other criteria on the PEDro scale.

Among the analyzed studies, one achieved the highest score of 9/10 [10], two obtained a score of 8/10 [4,11], one obtained a score of 7/10 [12], five obtained a score of 6/10 [5,13–16], and one had the lowest score of 5/10 [7]. According to the criteria proposed by Maher et al.[10], a score of 5/10 or higher was indicative of a high methodological quality, which applied to all the reviewed studies.

Risk of bias assessment using Cochrane scale

The risk of bias of the included randomized controlled trials was assessed using the Cochrane Risk of Bias 2.0 tool. Most studies demonstrated a low risk of bias across the five assessed domains, particularly in deviations from intended interventions (D2), completeness of outcome data (D3), and selective reporting of results (D5).

However, some concerns were identified in the domain related to the randomization process (D1), especially in the studies by Pippas et al.[11], and Quintana-Cepedal et al.[7] Additionally, isolated uncertainties in the domain of outcome measurement (D4) were observed in certain studies, potentially reflecting limitations in the blinding procedures or the objectivity of measurement tools.

Overall, the included trials were considered to be of moderate to high methodological quality, supporting the internal validity of this review. A detailed summary of domain-specific ratings and overall risk of bias is presented in Table 3.

Table 3
Item scores and final Cochrane ROB 2.0 scale rating for studies included in the systematic review.

Study	D1	D2	D3	D4	D5	General
Quintana-Cepedal et al.[7]	?	+	?	+	+	?
Pippas et al.[11]	?	+	?	?	+	?
Alsirhani et al.[12]	+	+	+	+	+	+
Fujisaki et al.[13]	+	+	+	?	+	?
Alonso-Fernández et al.[14]	+	+	+	+	+	+
Alonso-Calvete et al.[15]	+	+	+	+	+	+
Dawkins et al.[4]	+	+	+	+	+	+
Attar et al.[16]	+	+	?	+	+	?
Harøy et al.[17]	+	+	+	+	+	+
Ishøi et al.[5]	+	+	?	+	+	?

D1 = randomization process; D2 = deviations from scheduled interventions; D3 = outcome data; D4 = outcome measurement; D5 = result reporting

Characteristics of the studies included in the systematic review

In this section, the main characteristics of the included studies are presented, as well as the parameters of the CAE used in each intervention, providing more detailed and comparative information.

It should be noted that the included trials differed in their primary aims: two studies were designed primarily as injury-prevention interventions[17,13], whereas the remaining trials focused on strength, muscle architecture or symptom- and function-related outcomes in athletes with or without groin pain .[4,5,7,12,11,14–16] Given this heterogeneity in objectives but also the overlap in outcome measures, the characteristics of all studies are presented collectively in Tables 4 and 5.

Accordingly, Table 4 summarizes details regarding population and outcome measures, while Table 5 presents the CAE intervention parameters.

Table 4
Study characteristics. CAE = copenhagen adduction exercise; CA = copenhagen adduction; NHE = Nordic hamstring exercise; IG = intervention group; CG = control group; LVG = low-volume group; HVG = high-volume group; SQ = adductor squeeze; *Years (SD); EHAD = Eccentric Hip Adduction Strength; IHAD = Isometric hip adduction; ROM = range of motion.

Study	Design	Objective	Sample and characteristics*	
Quintana-Cepedal et al.[7]	Randomized controlled trial	Investigate the training and detraining effects of two different-volume CAE protocols on adductor squeeze strength	n = 30 LVG =13 .[14.0 years]; HVG =8 .[14.0 years]; CG = 9 .[14 (0.52) years]	Hockey
Pippas et al.[11]	Pragmatic randomized controlled trial	Examined the effect of assigning male soccer players to an 8-week CAE and SQ training protocols. Maximal EHAD and IHAD torque was tested.	n = 55 .[16.7 (0.9) years] CA = 29; SQ = 26	Soccer
Alsirhani et al.[12]	Randomized controlled trial	Investigate the impact of a rehabilitation program including CAE on EHAD, hip ROM, self-reported disability, and pain among soccer players with adductor-related groin pain.	n = 30 .[26.4 (3.9) years] IG = 15; CG = 15	Elite and Sub-Elite Soccer
Fujisaki et al.[13]	Cluster-randomized controlled trial	Evaluate the preventative effects of exercise on groin pain in high schools' soccer players with CAE and NHE interventions.	n = 202 CAE = 66 .[16.4 (4.3) years]; NHE = 73 .[16.0 (0.7 years)]; CG = 63 .[16.1 (0.9) years]	Soccer
Alonso-Fernández et al.[14]	Randomized controlled trial	Analyze the impact of the CAE on adductor muscle architecture and flexibility after training and detraining	n = 45 .[26.1 (2.8) years] IG = 25; CG = 20	Sporty people
Alonso-Calvete et al.[15]	Randomized controlled trial	Analyze the effects of the CAE on the muscle thickness of the adductors	n = 12 .[Under-17] IG = 6; CG = 6	Soccer
Dawkins et al.[4]	Randomized controlled trial	Investigate the training and detraining effects of a low-dose CAE intervention in sub-elite male soccer players on EHAD and peak adductor squeeze strength.	n = 39 IG = 20 .[19.5 (1.2) years]; CG = 19 .[19.3 (1.0) year]	Sub-elite soccer
Attar et al.[16]	Randomized controlled trial	Investigate the effects of CAE and NHE on dynamic balance in amateur male athletes	n = 177 .[21.9 (2.4) years] CAE = 42; NHE = 44; CAE + NHE = 47; CG = 44	Athletes (non-specific)
Harøy et al.[17]	Cluster-randomized controlled trial	Evaluate the effects of the CAE on the prevalence of groin problems in male soccer players.	n = 489 IG = 247 .[22.0 (4.3) years]; CG = 242 .[23.7 (4.3) years]	Semiprofessional soccer
Ishøi et al.[5]	Cluster-randomized controlled trial	Examine the EHAD gain using the CAE in-season.	n = 20 IG = 10 .[17.3 years]; CG = 10 .[17.4 years]	Sub-elite soccer

Participants, gender and age

A total of 1099 participants were analyzed across the included studies, all of whom were male. In one of the studies participant sex was not reported .[7]

Regarding sample size, four studies included more than 50 participants[11,17,13,16], while six studies analyzed samples with fewer than 50 participants .[4,5,7,12,14,15]

Most of the studies analyzed samples whose participants were between 16 and 24 years .[4,5,11,17,13,15,16] However, two studies reported a mean participant age over 26 years. One of these two studies reported a mean participant age of 26.1 ± 2.8 years[14] and the other study reported a mean participant age of 26.4 ± 3.9 .[12] In another study, the mean participant age was Under-14 .[7]

Sports and level

Most of the studies examined soccer players. In total, seven studies included soccer athletes: three did not specify competitive level[11,13,15], two included sub-elite players[4,5], one combined sub-elite and elite soccer players[12] and one analyzed semiprofessionals players .[17]

In addition, one study analyzed high-level Under-14[7] hockey players. Another study included athletes whose sport was not specified .[16] Finally, one study examined physically active individuals who participated in fitness activities, team sports, martial arts and athletics .[14]

Interventions with CAE

Regarding interventions with CAE and intervention parameters, six studies implemented an 8 weeks CAE program[5,7,12,11,14,15], two studies applied a 6 week program[4,16], one study lasted 16 weeks[13] and one study was conducted over a 28 weeks in season period .[17]

Five studies performed 2 weekly sessions[4,5,12,11,15], two studies performed between 2 and 3 weekly sessions depending on the intervention week[14,13], and one study prescribed between 1 and 2 sessions per week .[7] One study used a single weekly session[17] while another study performed 3 weekly sessions .[16]

In terms of sets performed, six studies performed between 22 and 48 sets .[5,12,11,14,17,13] Two studies performed below 16 sets[4,15], one study performed between 16 and 30 sets depending on the IG[7] and one study performed between 54 and 108 sets .[16]

Outcomes measures

Two studies measured maximal EHAD[5,11], two studies measured EHAD[4,12] and one study assessed adduction strength .[7] Two studies evaluated adductor muscles thickness[14,15] and one of these two also measured the hip abduction range .[14] One study assessed dynamic balance performance .[16] Another study evaluated the weekly prevalence of all groin problems and the weekly prevalence of substantial groin problems during competitive season .[17] Finally, one study measured the frequency and probability of groin pain .[13]

Discussion

The aim of this systematic review was to evaluate the influence of the CAE on the management of groin pain in athletes and physically active individuals. The main findings indicate that CAE interventions generally lead to improvements in several outcomes related to groin pain.

Beyond imaging-based assessments such as ultrasound and, in some studies, surface EMG, the included trials employed a wide range of clinical and functional evaluations that provide a broader understanding of groin function. These measures included strength-related assessments such as maximal EHAD and isometric adductor squeeze tests; range-of-motion assessments, primarily hip abduction ROM; functional performance tests, such as dynamic balance assessments using standardized

Table 5
Main findings of the included studies. CAE = Copenhagen adduction exercise; wk = weeks; wk/ss = weekly sessions; Reps = repetitions; BG = Beginner; IM = Intermediate; AV = Advanced; LVG = low-volume group; HVG = high-volume group; EHAD = Eccentric Hip Adduction Strength; IHAD = Isometric hip adduction; EHAB = maximal eccentric hip abduction strength; IG = intervention group; CG = control group; AL = adductor longus; LoS = limits of stability; SQ = adductor squeeze; NHE = Nordic hamstring exercise; ROM = range of motion.

Study	Intervention with CAE		Results	Conclusions
Quintana-Cepedal et al.[7]	8 wk 1-2 wk/ss	16 (LVG) – 30 (HVG) Sets 110-254 Reps	Adductor strength increase was significantly higher in HVG compared to LVG or controls. No significant strength drop was observed in any group	The CAE protocol performed twice a week enhances squeeze strength to a further extent compared to one weekly session.
Pippas et al.[11]	8 wk 2 wk/ss	32 Sets 272 Reps	There were no statistically significant between-group differences in eccentric or isometric hip adductor torque between the CAE and the SQ groups. The CAE group reported higher levels of DOMS compared to the SQ group during weeks 3-8 of the intervention.	The CAE or SQ training program did not result significant differences in eccentric nor isometric adduction torque between the groups.
Alsirhani et al.[12]	8 wk 2 wk/ss	32-48 Sets 192-480 Reps	Significant improvements within groups were observed across all measures. The IG demonstrated a greater increase in EHAD, a more pronounced reduction in pain and betterment in all HAGOS subscale scores compared to the CG.	Incorporating the CAE into rehabilitation programs significantly improves EHAD, decreases pain scores, and reduces self-reported disability in soccer players with adductor-related groin pain.
Fujisaki et al.[13]	16 wk 2-3 wk/ss	47 Sets 489-625 Reps	The CAE alone and CAE with NHE reduced groin pain incidence and player downtime than CG, with the combined intervention being more effective.	The CAE incorporating in training sessions reduced the incidence of groin pain, and the combination of the CAE and NHE may be more effective than the CAE alone.
Alonso-Fernández et al.[14]	8 wk 2-3 wk/ss	22 Sets 206 Reps	A significant increase in AL muscle thickness and adductor flexibility was found in IG.	The CAE resulted in a significant increase in AL muscle thickness and hip abduction ROM. These changes were reversed after a detraining period.
Alonso-Calvete et al.[15]	8 wk 2 wk/ss	16 Sets 176 Reps	Both the CAE group and the CG showed significant increases in AL muscle thickness over the 8-week period.	The CAE does not increase the muscle thickness of the adductor longus more than their regular training program.
Dawkins et al.[4]	6 wk 2 wk/ss	12 Sets 55 Reps	There was no between-group difference in eccentric strength at week 6 and 9. There was a significant group by time interaction at 6 weeks and 9 weeks at which the IG displayed greater adductor squeeze strength.	A low-dose CAE intervention did not improve EHAD, but that intervention did improve peak adductor squeeze strength in the IG compared to the CG.
Attar et al.[16]	6 wk 3 wk/ss	54 (BG, IM) – 108 (AV) Sets 324-864 Reps	The LoS significantly improved in all treatment groups when compared with the CG. The improvement was significantly greater in the CAE + NHE group compared with other groups.	CAE and NHE lead to significant improvements in dynamic balance compared to a CG
Harøy et al.[17]	28 wk 1 wk/ss	28 Sets 336-420 Reps	The average prevalence of groin problems during the season was 13.5% in the IG and 21.3% in the CG. The risk of reporting groin problems was 41% lower in the IG.	The simple Adductor Strengthening Program substantially reduced the self-reported prevalence and risk of groin problems
Ishøi et al.[5]	8 wk 2 wk/ss	42 Sets 480 Reps	The IG demonstrated a 35.7% increase in EHAD using the CAE. The IG also showed a 20.3% increase in EHAB strength and 12.3% increase in EHAD/EHAB ratio.	The CAE implemented in-season with an 8-week progressive training program elicited a large significant increase in EHAD, EHAB, and EHAD/EHAB ratio

Table 6
Practical Recommendations for Implementing the CAE.

Goal	Frequency	Volume	Progression	Duration	Practical Application
Prevention (Team Sports)	1–3 sessions/week	300–600 total reps	Weekly rep increases; moderate–high volume	8–16 weeks	Integrate CAE into warm-ups or early session blocks; strongest evidence for reducing groin injury risk.
Rehabilitation (Athletes with Groin Pain)	2–3 sessions/week	180–320 reps	Symptom-guided progression; start with lower reps	8 weeks	Begin with short-lever CAE; progress based on tolerance; ideal for mid-stage rehab and return-to-play transitions.
Strength / Hypertrophy (Healthy Athletes)	2–3 sessions/week	200–400 reps	Add reps or external load weekly	8–16 weeks	Included in main strength session; high-volume CAE increases adductor strength and muscle thickness.
Neuromuscular / Balance Training	2–3 sessions/week	300–420 reps	Combine with NHE or balance drills	6–12 weeks	Useful in pre-season warm-ups or neuromuscular training circuits to enhance stability.
Youth Athletes	1–2 sessions/week	150–220 reps	Moderate progression	8 weeks	Introduce gradually; best during warm-ups or low-load sessions; avoid excessive soreness.

protocols; and pain- and symptom-related outcomes, including HAGOS subscales, self-reported pain scores, and weekly prevalence of groin problems during training and competition. The use of such heterogeneous outcome measures reflects the multifactorial nature of groin-related dysfunction and supports a more comprehensive interpretation of how the CAE influences strength, symptoms, and neuromuscular performance across different athletic contexts.

Among the ten studies included in this review, seven reported improvements in at least one outcome related to groin pain management following CAE interventions. In contrast, three studies[4,11,15] did not report significant changes in the assessed variables. These studies shared several characteristics, such as shorter intervention durations, fewer weekly sessions, or a lower total training volume, which may have limited the effectiveness of the intervention. Taken together, these

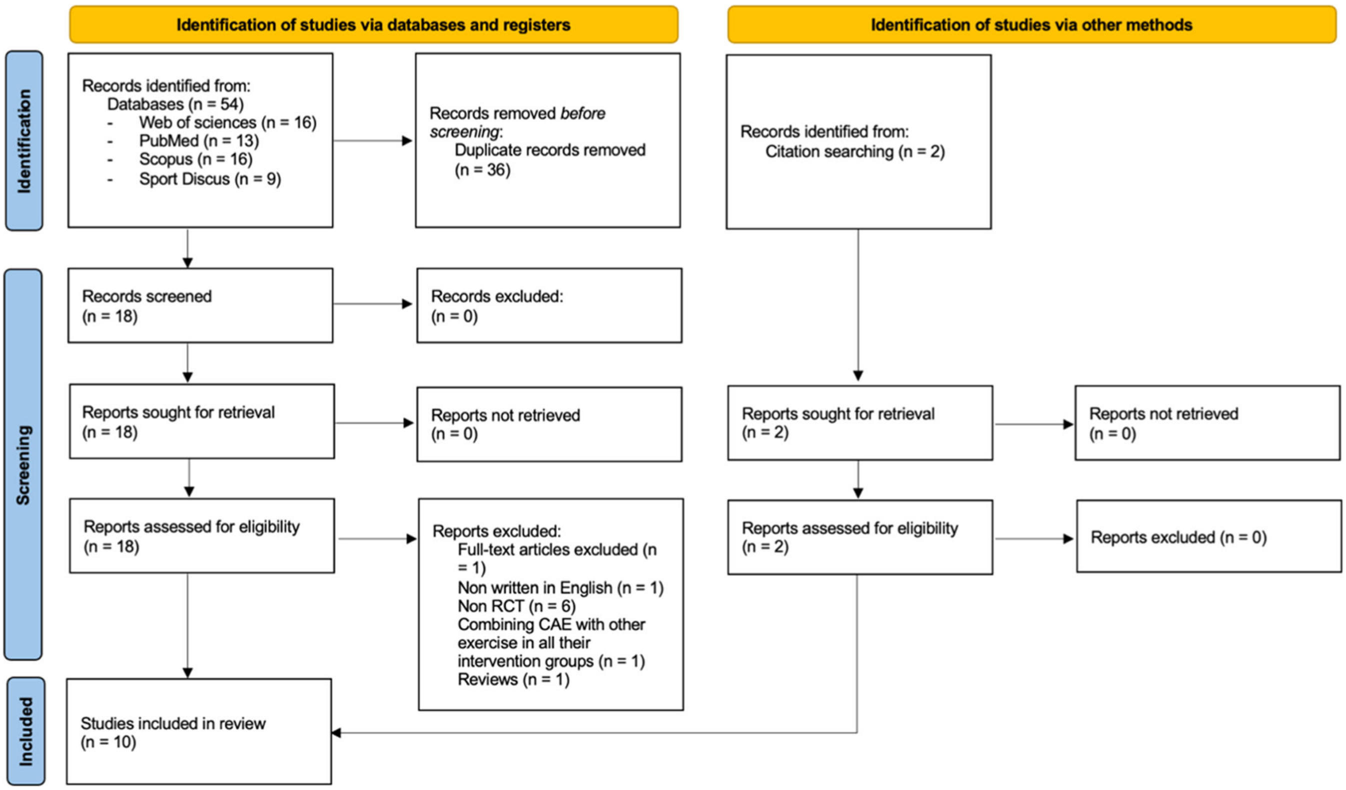

Fig. 1. Flowchart of the study selection process.

findings suggest that studies using longer intervention periods (around ≥8 weeks) and higher cumulative exposure (approximately >200 total repetitions) tended to report more consistent improvements. However, this apparent threshold should be interpreted with caution, as it arises from indirect patterns observed across heterogeneous study designs rather than from trials explicitly comparing different CAE volumes or durations. Higher training doses may enhance outcomes through increased neuromuscular activation, repeated eccentric loading stimulus, improved motor control of the hip and pelvic stabilizers, and progressive architectural adaptation of the adductors. At the same time, several studies have reported substantial delayed-onset muscle soreness (DOMS) and reduced adherence during higher-volume protocols, particularly in the early weeks or when implemented in-season, indicating that the relationship between training volume and effectiveness is not linear. Consequently, although greater exposure appears to favor more robust adaptations, optimal dosing should be tailored to athletes' tolerance, clinical presentation, and timing within the competitive calendar rather than applied as a fixed threshold.

This finding aligns with the dose-response relationship proposed by Quintana-Cepedal et al.[7] who showed that a high-volume CAE protocol produced significantly greater improvements in adductor squeeze strength compared to a low-volume approach, with the effects persisting even after detraining period. Additionally, O'Connor et al.[18] found that integrating external load into isometric CAE (i.e., weighted CAE) led to superior gains in the adduction/abduction strength ratio compared to the unweighted version, suggesting that both volume and intensity are key parameters for maximizing adaptations.

Notably, Dawkins et al.[4] observed increases in peak adductor squeeze strength despite the absence of changes in EHAD, a pattern that echoes the low-dose findings in the O'Connor study. This may indicate partial neuromuscular adaptations even with minimal stimulus, though potentially insufficient to elicit eccentric strength gains, an important consideration given the established association between EHAD and injury prevention.

Strong evidence from randomized controlled trials also supports the use of CAE for injury prevention. Harøy et al.[17] and Fujisaki et al.[13] demonstrated reductions of 30–41% in groin injury incidence among male soccer and high school athletes compared to standard training protocols. These findings are further supported by both earlier and more recent meta-analyses[6,19,20], which highlight the consistent strength gains achieved following CAE interventions. The high neuromuscular demand and eccentric nature of CAE likely play a key role in enhancing adductor resilience.

Regarding dynamic balance, one study included in this review[16] reported positive effects, and these results are corroborated by the RCT by Al Attar et al.[16] with over 200 participants, which showed significant improvements in balance metrics when CAE was performed either alone or in combination with NHE. This suggests potential broader neuromuscular benefits of CAE beyond adductor strength alone.

Although the included studies comprised a combined sample of approximately 1,099 participants, all were conducted exclusively in male athletes. This represents an important limitation, as groin injuries also affect female athletes, and recent evidence indicates that women may exhibit different baseline hip adductor strength profiles, neuromuscular activation strategies, and adaptation patterns to eccentric loading. These sex-related differences suggest that the responses to the CAE observed in male cohorts cannot be assumed to generalize to female populations. Therefore, the applicability of the present findings is limited, and future research should prioritize the inclusion of female athletes to determine whether CAE-related adaptations differ across sexes.

Although this review focuses on the CAE as a strengthening exercise for the hip adductors, it is important to acknowledge that the movement is not functionally isolated. EMG-based studies have shown that the CAE requires substantial coactivation of trunk stabilizers and pelvic musculature to maintain alignment and control the long-lever position, as well as contributions from upper and lower limb muscles across the kinetic chain .[11,21] These synergistic muscular demands may influence performance and adaptation outcomes, suggesting that improvements attributed to the CAE may also reflect broader neuromuscular engagement rather than isolated adductor activation. Similarly, studies using ultrasound imaging have reported that hypertrophic adaptations may reverse after short periods of detraining, highlighting the need for program continuity .[15]

Few studies were found that evaluated and used CAE as the only exercise in the IG, which makes it difficult to guarantee that the observed effects can be attributed exclusively to the CAE, particularly because most interventions were performed alongside regular sport-specific training. Nevertheless, as shown in this review, studies that implemented the CAE as the primary or isolated component generally reported improvements in strength, function or symptom-related outcomes, suggesting that the CAE may provide meaningful benefits even when not embedded within comprehensive prevention programs. However, the scarcity of trials using CAE as a stand-alone intervention likely reflects both methodological and practical constraints. In real-world settings, the CAE is typically integrated into broader prevention or rehabilitation programs, together with other neuromuscular, strength and sport-specific exercises, rather than being implemented in isolation. Recent reviews have noted that most CAE-based protocols are combined with additional training elements, limiting the ability to isolate its independent effects .[1,19] Likewise, current recommendations for hip and groin injury prevention favor multifactorial approaches that include adductor strengthening, trunk and pelvic stabilization, load management and movement control strategies .[3,17] From a methodological and ethical perspective, isolating the CAE would require substantial restrictions or modifications to athletes' usual training routines, which is often infeasible in applied sport environments.

Distinguishing prevention- and rehabilitation-oriented applications of the CAE is essential for accurate interpretation and clinical translation of the findings. The two injury-prevention trials included in this review[17,13] primarily assessed the incidence of groin problems over a competitive season and implemented high-volume, progressive CAE protocols integrated into team training. In contrast, the rehabilitation-focused studies[12,11] evaluated symptom severity, pain, hip adduction strength, and functional capacity in athletes with established groin pain, typically using lower weekly volumes and closer supervision. Strength- and architecture-focused trials[4,5,7,14–16] further differ in design, as they targeted neuromuscular adaptation rather than injury risk or symptom resolution. Importantly, the parameters used in preventive programs, characterized by higher volume and longer duration, may not be directly transferable to rehabilitation contexts, where pain irritability and tissue tolerance require more cautious progression. Conversely, the lower volumes used in rehabilitation studies may be insufficient to achieve the exposure thresholds associated with injury-preventive effects. Therefore, while the CAE appears beneficial across domains, the optimal volume, frequency, and progression are likely context dependent, and clinicians should tailor the prescription according to whether prevention, symptom reduction, or structural adaptation is the primary target.

Furthermore, several of the included trials combined the CAE with additional training components, such as the Nordic Hamstring Exercise, general strength routines, or regular team training .[13,16,19] This makes it even more challenging to isolate the specific contribution of the CAE to the observed outcomes. When multiple exercises targeting related neuromuscular capacities are administered simultaneously, improvements in strength, balance, or injury prevalence may result from cumulative or synergistic effects rather than from the CAE alone.

The substantial methodological heterogeneity across the included studies further limits the strength of the conclusions drawn from this review. The trials differed markedly in CAE progression parameters (sets, repetitions, weekly frequency, and use of external load), participant characteristics (age ranges, competitive levels, and baseline symptom status), and the extent to which the CAE was combined with other exercises such as the NHE or general strength routines .[4,5,12,11,14,13,15,16] This variability complicates direct comparison of effects and reduces confidence in identifying optimal training parameters for specific clinical contexts. Moreover, the diversity in outcome measures and intervention designs precluded the pooling of data for a meta-analysis, as combining such heterogeneous protocols would risk producing misleading or clinically uninterpretable estimates.

To facilitate clinical application of the present findings and in line with reviewer recommendations, we provide a set of practical guidelines summarizing frequency, volume, progression strategies, and typical duration of CAE-based interventions according to their intended purpose. These recommendations are derived from the parameters used in the included randomized trials and should be interpreted as evidence-informed guidance rather than prescriptive protocols.

This potential injury-preventive effect is supported by evidence showing that increases in EHAD enhance the tissue's ability to tolerate high mechanical loads and reduce adductor–abductor strength imbalances, both of which are recognized risk factors for groin injuries. In addition, recent meta-analyses have consistently reported substantial gains in adductor strength following CAE interventions[19], which are closely associated with reduced injury risk.

Future research should include more diverse populations (e.g., women and non-athletes), isolate CAE's effects, standardize protocols, and assess long-term outcomes to improve real-world implementation and guide clinical practice.

Conclusion

The CAE appears to be an effective intervention for improving and managing groin-related outcomes in male athletes. Evidence from randomized trials supports its preventive potential, while its rehabilitative applicability is suggested by consistent improvements in strength and symptom-related variables across studies. Given that all included studies examined only male athletes, the generalizability of these findings to female populations remains limited, and future research should determine whether CAE-induced adaptations differ across sexes. Although further research is needed to confirm these effects in broader populations, the current body of evidence supports its inclusion in conditioning and injury-prevention programs.

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Conflicts of interest

The Authors declare that they don't have any conflict of interests

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