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COMPARATIVE EFFECTS OF POST ISOMETRIC RELAXATION TECHNIQUE AND COPENHAGEN ADDUCTOR STRENGTHENING EXERCISE PROGRAM FOR FUNCTIONAL DISABILITY MANAGEMENT IN ATHLETES WITH GROIN INJURY

Original Research

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ABSTRACT

Background: Groin injuries are highly prevalent in athletes, particularly in sports requiring sprinting, kicking, or sudden directional changes, and are associated with significant pain, functional limitations, and time loss from play. Conservative physiotherapy-based interventions such as Copenhagen Adduction Exercises (CAE) and Post-Isometric Relaxation (PIR) have shown potential therapeutic benefits. However, evidence directly comparing their effectiveness in reducing pain and improving function in athletes with groin injuries remains limited, underscoring the need for further clinical evaluation.

Objective: To compare the effects of CAE and PIR on pain intensity and functional disability among athletes presenting with groin injuries.

Methods: A randomized controlled trial was conducted on 40 professional athletes aged 18–27 years who met specific inclusion criteria. Participants were randomly allocated into two groups of 20 each. Group A received PIR combined with routine physical therapy, while Group B received CAE alongside routine physical therapy. Interventions were delivered three times per week for six weeks. Pain was measured using the Numeric Pain Rating Scale (NPRS), symptoms were assessed through the Oslo Sports Trauma Research Center (OSTRC) Overuse Injury Questionnaire, and functional outcomes were evaluated with the Copenhagen Hip and Groin Outcome Score (HAGOS). Assessments were performed at baseline, three weeks, and six weeks. Data were analyzed using repeated measures ANOVA and independent sample t-tests with a significance threshold of $p \leq 0.05$.

Results: The mean NPRS at baseline was 3.70 in the PIR group and 3.55 in the CAE group, with reductions to 2.80 and 1.60 respectively by week six ($p = 0.000$). OSTRC scores improved from 3.80 to 2.95 in the PIR group and from 3.95 to 1.00 in the CAE group ($p = 0.000$). HAGOS scores decreased from 4.40 to 3.20 in the PIR group and from 4.00 to 1.15 in the CAE group ($p = 0.000$). Both groups improved significantly over time; however, CAE demonstrated superior outcomes across all measures.

Conclusion: Both CAE and PIR effectively reduced pain and functional disability in athletes with groin injuries, but CAE yielded significantly greater improvements. These findings highlight the clinical value of eccentric adductor strengthening as an effective rehabilitation strategy for athletes.

Keywords: Athletes, Exercise Therapy, Groin Injuries, Hip Joint, Muscle Strength, Physical Therapy Modalities, Rehabilitation.

INTRODUCTION

Groin injuries represent a common yet diagnostically challenging problem in sports medicine, particularly among football players and athletes engaged in high-intensity physical activity. A groin injury is generally defined as a strain affecting the hip adductor muscles or associated structures, often characterized by localized tenderness, pain on resisted hip adduction, and discomfort during activity (1). While historically described as a singular entity, this oversimplification neglects the anatomical and functional complexity of the groin region, where multiple structures may be simultaneously compromised. The concept of "adductor-related groin pain" was first introduced in 1998, and subsequent literature has identified three main clinical entities as primary contributors to groin-related pain: adductor-related, abdominal-related, and iliopsoas-related, with adductor-related pain being the most prevalent (2,3). Groin pain in athletes is influenced by a multifactorial etiology and complex symptomatology, making it a significant diagnostic and therapeutic challenge for clinicians (4,5). Risk factors include both non-modifiable variables such as age and anthropometric characteristics, and modifiable elements such as hip range of motion, muscle strength, and sport-specific conditioning. High-level evidence highlights that a history of prior groin injury, insufficient rehabilitation, decreased adductor strength, and inadequate preseason training significantly increase the likelihood of recurrence (6). Male athletes, particularly football players, report higher incidences of groin injuries, accounting for up to 19% of time-loss injuries, compared to 14% in females, underscoring a gender disparity in susceptibility (7,8). The epidemiology of groin injuries demonstrates their substantial impact on athletic performance. Prospective studies in football have shown prevalence rates as high as 20% in-season, with recurrent injuries being strongly associated with reduced hip adductor strength and previous episodes of pain (9). Although some cases do not result in significant time loss, recurrent or chronic groin pain often disrupts training continuity, prolongs recovery, and can even contribute to premature career termination.

Preventive and therapeutic strategies have evolved substantially over the last two decades. Structured injury prevention programs such as FIFA 11+ have demonstrated reductions of up to 39% in hip and groin injuries by combining warm-up, strengthening, coordination, and plyometric exercises (10,11). Specific strengthening interventions such as the Copenhagen Adductor Exercise (CAE) have shown particular promise by targeting eccentric adductor strength and improving muscle balance, thereby reducing the risk of injury recurrence (12). Comparative trials in other musculoskeletal conditions have also demonstrated the value of evaluating distinct physiotherapy approaches to optimize pain relief and function (13). In addition, Muscle Energy Techniques (METs), particularly post-isometric relaxation, have been explored as adjunctive therapies, with early findings indicating benefits in pain modulation and muscle function (14). However, robust comparative trials between CAE and MET-based approaches remain lacking, leaving clinicians without definitive evidence on which strategy offers superior rehabilitative outcomes. Current literature emphasizes that active exercise-based protocols, particularly those incorporating progressive strengthening and sport-specific training, provide the best-documented results for both prevention and rehabilitation of groin injuries (15,16). Yet, no gold standard management protocol has been universally established. Clinical reviews stress the importance of early detection, individualized rehabilitation, and multimodal management strategies to prevent chronicity (17). Moreover, the lack of standardized clinical guidelines continues to limit uniform implementation across athletic levels. Given the high prevalence of groin injuries, their recurrent nature, and the absence of conclusive evidence comparing specific rehabilitation strategies, further research is required to optimize treatment protocols. This study aims to compare the effectiveness of Copenhagen Adductor Exercise and post-isometric relaxation exercises in managing groin pain among athletes, with the objective of providing clinically relevant evidence to guide prevention and rehabilitation practices in sports medicine.

METHODS

This study was designed as a randomized clinical trial with a single-blinded approach. It was conducted over a period of six months at the outpatient department of the Rehabilitation Clinic, Bakhtawar Amin College of Rehabilitation Sciences. Prior to commencement, ethical approval was obtained from the Research Ethics Committee of Riphah College of Rehabilitation Sciences, Riphah International University, Lahore. The study was conducted in accordance with the principles of the Declaration of Helsinki, and written informed consent was obtained from all participants before enrollment. Confidentiality of personal data was maintained throughout, and athletes were informed of their right to withdraw at any stage without consequence. A total of forty professional athletes were recruited and equally divided into two groups. The sample size was calculated using a statistical formula, accounting for a 10% dropout rate, with a

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study power of 90% (β = 0.10) and a significance level of 95% (α = 0.05). The calculation was based on an expected mean difference in outcomes of 10.25, with reference values of 22.30 and 22.50, and standard deviations of 4.71 for the experimental group and 5.57 for the control group. This resulted in a final allocation of 20 participants per group. Participants were randomly assigned into two intervention groups using the lottery method. Group A received post-isometric relaxation techniques in combination with routine physical therapy, whereas Group B received the Copenhagen adductor strengthening exercise alongside routine physical therapy.

The inclusion criteria comprised professional athletes of either gender, aged between 18 and 27 years, who reported groin pain either at rest or during sporting activity (11). Symptoms required for inclusion included pain, ache, stiffness, clicking or catching sensations, or any other groin-related complaints (16). Additionally, athletes were included if groin-related issues had led to reduced participation in training or decreased performance, and if they expressed willingness to participate in the study (18). Exclusion criteria encompassed any athlete with a history of lower limb trauma requiring medical care within the preceding six months, a history of surgical intervention or systemic illness within the last year, or a previous lower extremity fracture (11). The sampling technique applied was non-probability purposive sampling, which should be noted as a methodological limitation because purposive recruitment may introduce selection bias and affect generalizability of findings. Each intervention was delivered three times per week over six weeks. Group A underwent conservative physiotherapy in addition to post-isometric relaxation techniques specifically targeting the adductor muscle group. Group B received conservative physiotherapy combined with the Copenhagen Adductor Exercise, performed in a side plank position with eccentric and concentric hip adduction movements supported by a partner. Both interventions were designed to address muscle imbalance and restore hip adductor strength.

Data collection involved three validated instruments. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), groin-related symptoms were measured with the Oslo Sports Trauma Research Center (OSTRC) Overuse Injury Questionnaire, and hip/groin functional outcomes were evaluated using the Copenhagen Hip and Groin Outcome Score (HAGOS). Assessments were conducted at baseline, three weeks, and six weeks. Data were analyzed using SPSS version 24. Numerical variables such as age, weight, and height were presented as mean ± standard deviation, while categorical data such as gender distribution were expressed as frequencies and percentages. Normality of data was confirmed prior to analysis. Between-group comparisons were conducted using the independent sample t-test to evaluate mean differences in pain, range of motion, and functional disability. Repeated measures ANOVA was used to compare outcome variables across the three time points. A p-value of ≤0.05 was considered statistically significant.

RESULTS

The study included forty athletes aged between 18 and 25 years, with a mean age of 21.25 ± 2.26 years. The most common ages were 20 and 24 years, each representing 20% of the sample, while 18 years accounted for 15% and 25 years for 5%. Males comprised the majority of participants (75%), whereas females accounted for 25%. Regarding the type of sport, 40% were footballers, 30% hockey players, 12.5% runners, 7.5% volleyball players, and 5% each were cricketers and athletes from other sports. In terms of injury laterality, 45% reported right-sided groin involvement, 40% had left-sided injuries, and 15% presented with bilateral groin pain. The Shapiro–Wilk test confirmed data normality, with p-values greater than 0.05 for all baseline variables, allowing the use of parametric statistical tests. Pain intensity, assessed using the Numeric Pain Rating Scale (NPRS), demonstrated improvements in both intervention groups, although more pronounced in the Copenhagen Adductor Exercise group. At baseline, mean pain scores were 3.70 for the post-isometric relaxation group and 3.55 for the Copenhagen group. At the third week, scores were 3.70 and 2.50 respectively, while by the sixth week, they decreased to 2.80 and 1.60. Independent t-test analysis revealed no significant baseline differences (p = 0.340), but significant differences were observed at the third week (p = 0.000) and sixth week (p = 0.000). The Oslo Sports Trauma Research Center (OSTRC) overuse injury scores showed a similar trend. Baseline values were 3.80 for the post-isometric group and 3.95 for the Copenhagen group. At the third week, these values were 3.75 and 2.70 respectively, and by the sixth week, they decreased further to 2.95 and 1.00. Statistical analysis showed non-significant differences at baseline (p = 0.246), while highly significant differences were found at the third week (p = 0.000) and sixth week (p = 0.000).

The Copenhagen Hip and Groin Outcome Score (HAGOS) also reflected superior outcomes in the Copenhagen group. At baseline, mean scores were 4.40 and 4.00 for the post-isometric and Copenhagen groups respectively. By the third week, these reduced to 3.95 and 3.00, and at the sixth week, they were 3.20 and 1.15. Differences between groups were not significant at baseline (p = 0.050), but highly significant differences were observed at both the third week (p = 0.000) and the sixth week (p = 0.000). Multivariate analysis confirmed these findings across all outcome measures. For NPRS, OSTRC, and HAGOS scores, Pillai's Trace, Wilks' Lambda, Hotelling's Trace,

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and Roy's Largest Root all demonstrated statistically significant results ($p < 0.05$). Between-subjects effects analysis further confirmed significant differences between groups ($p = 0.000$). Overall, both intervention groups demonstrated improvement over the six-week intervention period. However, athletes who underwent Copenhagen Adductor Strengthening exercises achieved significantly greater reductions in pain intensity, fewer overuse symptoms, and superior functional recovery compared to those receiving post-isometric relaxation techniques.

Table 1: Independent sample test for OSTRC Overuse injury

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
OSTRC-Overuse Injury questions about groin region Baseline	Equal variances assumed	6.236	.017	-1.179	38	.246	-.15000	.12722	-.40754	.10754
	Equal variances not assumed			-1.179	25.718	.249	-.15000	.12722	-.41164	.11164
OSTRC-Overuse Injury questions about groin region 3rd week	Equal variances assumed	.047	.009	6.489	38	.000	1.05000	.16182	.72242	1.37758
	Equal variances not assumed			6.489	37.100	.000	1.05000	.16182	.72216	1.37784
OSTRC-Overuse Injury questions about groin region 6th week	Equal variances assumed	36.351	.000	7.065	38	.000	1.95000	.27601	1.39124	2.50876
	Equal variances not assumed			7.065	19.000	.000	1.95000	.27601	1.37229	2.52771

Table 2: Independent sample test for HAGOS score

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference		95% Confidence Interval of the Difference	
									Lower	Upper
Copenhagen Hip and Groin Outcome Score (HAGOS) Baseline	Equal variances assumed	1.291	.263	2.027	38	.050	.40000	.19735	.00048	.79952
	Equal variances not assumed			2.027	37.752	.050	.40000	.19735	.00040	.79960
Copenhagen Hip and Groin Outcome Score (HAGOS) 3rd week	Equal variances assumed	1.055	.011	8.324	38	.000	.95000	.11413	.71895	1.18105
	Equal variances not assumed			8.324	27.543	.000	.95000		.71603	1.18397
Copenhagen Hip and Groin Outcome Score (HAGOS) 6th week	Equal variances assumed	.669	.009	16.665	38	.000	2.05000		1.80098	2.29902
	Equal variances not assumed			16.665	37.521	.000	2.05000		1.80087	2.29913

Table 3: Multivariate test for OSTRC overuse injury

Effect		Value	F	Hypothesis df		Sig.
factor1	Pillai's Trace	.700	44.277b	2.000	38.000	.000
	Wilks' Lambda	.300	44.277b	2.000		.000
	Hotelling's Trace	2.330	44.277b	2.000		.000
	Roy's Largest Root	2.330	44.277b	2.000		.000

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Table 4: Multivariate test for HAGOS Score

Effect		Value	F	Hypothesis df	Error df	Sig.
factor1	Pillai's Trace	.806	78.743b	2.000	38.000	.000
	Wilks' Lambda	.194	78.743b	2.000	38.000	.000
	Hotelling's Trace	4.144	78.743b	2.000	38.000	.000
	Roy's Largest Root	4.144	78.743b	2.000	38.000	.000

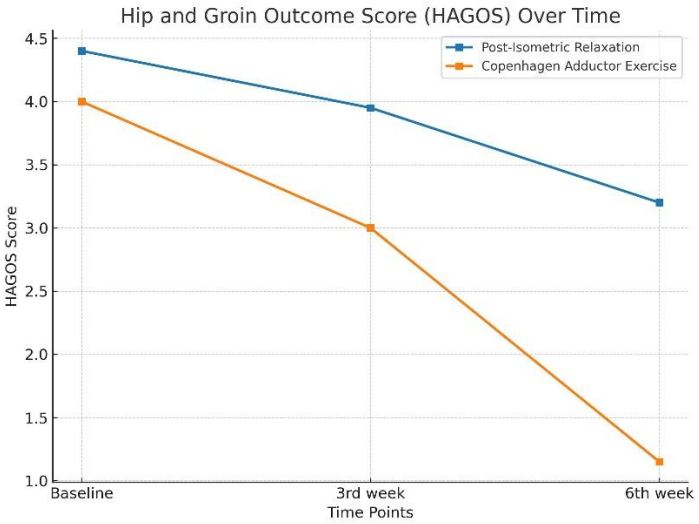

Figure 1 Hip and Groin Outcome Score (HAGOS) Over Time

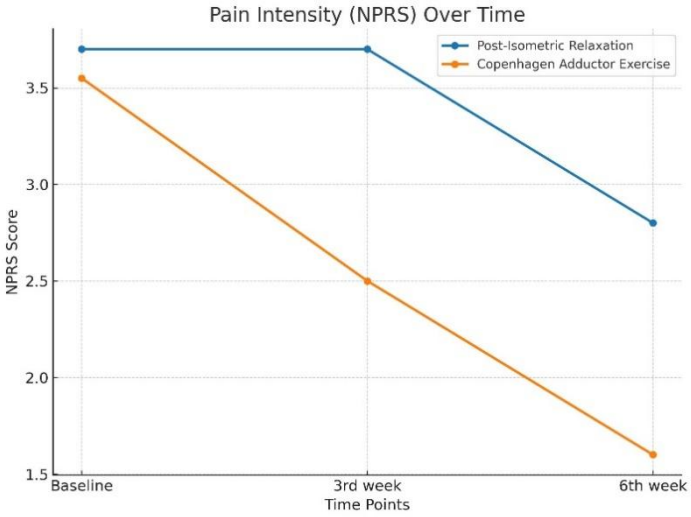

Figure 2 Pain Intensity (NPRS) Over Time

DISCUSSION

The present study demonstrated that both Copenhagen Adductor Exercise (CAE) and Post-Isometric Relaxation (PIR) techniques were effective in reducing pain and improving functional disability among athletes with groin-related pain, although CAE consistently produced greater improvements. The observed reductions in pain intensity, OSTRC overuse injury scores, and improvements in HAGOS functional outcomes across six weeks highlight the potential of CAE as a superior intervention compared to PIR. These findings contribute to the growing body of evidence supporting exercise-based strategies in the management of groin injuries. Comparable randomized trials in other musculoskeletal conditions, such as anterior cruciate ligament (ACL) rehabilitation, have also confirmed the effectiveness of structured physiotherapy interventions in improving muscle strength, range of motion, and functional performance (17). The superiority of CAE in improving eccentric hip adduction strength, the eccentric adduction-to-abduction strength ratio (EHAD: EHAB), and the activation of hip adductors through enhanced electromyographic activity has been well established in literature (18). This study's results aligned with earlier findings that eccentric adductor strengthening exercises not only reduce groin pain but also lower the risk of recurrence and enhance athletic performance. Previous trials have reported significant increases in eccentric adductor strength of up to 24–25% and abductor strength of 10–13% following CAE, with a 41% lower prevalence of groin problems in athletes compared to control groups (19). The present findings are consistent with these outcomes, further strengthening the evidence that CAE is both preventive and rehabilitative. In contrast, PIR has shown promising results in the management of acute and chronic musculoskeletal pain syndromes but lacks robust evidence supporting its effectiveness in athletes with groin-related injuries. While PIR may provide temporary relief through mechanisms such as post-isometric relaxation and increased pain pressure thresholds, the limited evidence base makes it less reliable as a standalone intervention for long-term rehabilitation in groin pain (20,21). The current findings suggest that although PIR contributes to symptomatic improvement, CAE is more effective in producing consistent reductions in pain and enhancing functional outcomes.

The results of this study were also comparable to those of trials that contrasted CAE with other exercise-based protocols. In some studies, CAE and sliding hip exercises showed no significant difference in muscle strength outcomes, suggesting that both interventions were effective in restoring EHAD and EHAB balance (22). Other research demonstrated that CAE was superior to standardized programs such as FIFA 11+, with significant improvements in eccentric adduction strength observed only in the CAE group (23). These findings resonate with the outcomes of this trial, where CAE provided a greater degree of improvement than PIR across all measured parameters. Nevertheless, not all evidence supports CAE unequivocally. Certain randomized trials have reported structural adaptations such as increased muscle thickness in both intervention and control groups, suggesting that improvements may not be due to CAE alone (24). Other studies evaluating low-dose CAE programs observed no significant increases in eccentric adductor muscle strength, although greater adductor squeeze strength was noted (25). These mixed findings indicate that the dosage, intensity, and duration of CAE protocols play an essential role in determining clinical effectiveness, which warrants further investigation. The implications of this study are particularly relevant for physiotherapists and sports medicine practitioners. CAE offers a practical, sport-specific, and easily implementable strategy to improve adductor strength and reduce groin pain in athletes (26). PIR, while less effective as a primary intervention, may still serve as a complementary modality, particularly for individuals with acute musculoskeletal pain or those unable to perform eccentric strengthening due to discomfort. Incorporating CAE into preseason conditioning and rehabilitation programs may therefore reduce the prevalence of groin injuries and improve return-to-play outcomes.

Several strengths of this study enhance its credibility. The randomized controlled trial design with blinded outcome assessment minimized bias, while validated outcome measures such as NPRS, OSTRC, and HAGOS ensured reliable assessment of pain and functional disability. The structured six-week intervention period with multiple follow-up points provided insights into both short-term and progressive effects. However, certain limitations must be acknowledged. The sample size, though statistically powered, was relatively small and limited to a specific athletic population, reducing generalizability. The recruitment method was purposive, which may have introduced selection bias. Moreover, outcomes were primarily self-reported and subjective, with no objective assessment of muscle strength or imaging-based evaluation of structural adaptations. This reliance on subjective tools may limit the accuracy of the findings. Additionally, participants were not blinded to the intervention they received, which may have introduced performance bias. The absence of range of motion or biomechanical outcome data, despite being mentioned in the methodology, represents another limitation that weakens the comprehensiveness of the results. Future studies should employ larger, more diverse populations and include objective strength testing and imaging assessments to validate functional improvements. Comparative studies exploring different dosages and intensities of CAE, as well as combining PIR with CAE, could also provide valuable insights. Long-term follow-up would be essential to evaluate sustainability of benefits and recurrence rates of groin pain. In conclusion, both interventions proved beneficial in reducing groin pain and disability, but CAE emerged as the more effective strategy. These findings reinforce the importance of eccentric adductor strengthening in the rehabilitation and prevention of groin injuries in athletes, while highlighting the need for further research to refine protocols and validate outcomes with objective measures.

CONCLUSION

This randomized controlled trial concluded that both Copenhagen Adduction Exercises and Post-Isometric Relaxation techniques were beneficial in alleviating groin pain and improving functional ability in athletes, yet Copenhagen Adduction Exercises produced more pronounced outcomes. These findings emphasize the importance of incorporating eccentric adductor strengthening into rehabilitation and preventive strategies for athletes, offering a practical and evidence-based approach to reduce injury burden and enhance athletic performance.

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AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Asif Javed*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Adeela Shahid	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Maria Umar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Nida Shahzad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Faiza Sarwar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Asma Akram	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Nadia Rehman	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Kainat Jaffary	Writing - Review & Editing, Assistance with Data Curation

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