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Effect Of Closed Chain Exercises Versus Open Chain Exercises on Pain and Foot Function Among Young Female Athletes with Ankle Sprain: A Comparative Study

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ABSTRACT

Background: Ankle sprains are among the most common musculoskeletal injuries in athletes, particularly young females, due to anatomical and neuromuscular factors. These injuries can lead to chronic ankle instability (CAI), functional limitations, and long-term disability if not properly rehabilitated. Closed kinetic chain (CKC) and open kinetic chain (OKC) exercises are commonly used in rehabilitation, but comparative evidence regarding their efficacy in young female athletes is limited.

Need of the Study: While physiotherapy interventions for ankle sprains are well-established, few studies have directly compared the impact of CKC versus OKC exercises, especially in combination with cryotherapy, in young female athletes. There is a need to identify the most effective rehabilitation strategy to reduce pain and improve function, thereby preventing recurrence and promoting safe return to sport.

Methodology: This comparative study involved 60 female athletes aged 18–25 with Grade I or II ankle sprains. Participants were randomly assigned to either a CKC group (n=30) or an OKC group (n=30). Both groups underwent supervised exercise sessions 4 times a week for 6 weeks, alongside cryotherapy. Outcome measures included the Foot and Ankle Disability Index (FADI) and the Visual Analog Scale (VAS) for pain, assessed pre- and post-intervention. Statistical analysis was performed using paired and independent t-tests.

Results: Both groups showed significant improvements in pain and function ($p<0.0001$). The CKC group demonstrated greater gains, with a FADI improvement of +16.80 points and a VAS reduction of –2.67 points, compared to the OKC group's +10.64 FADI improvement and –1.36 VAS reduction ($p<0.0001$ for between-group comparisons).

Conclusion: Closed kinetic chain exercises are significantly more effective than open chain exercises in reducing pain and improving foot function among young female athletes with ankle sprains. CKC exercises should be prioritized in rehabilitation protocols for this population.

Keywords: *Ankle Sprain, Closed Kinetic Chain Exercises, Open Kinetic Chain Exercises, Female Athletes, Rehabilitation, FADI, VAS, Proprioception*

1. INTRODUCTION

The ankle joint is a complex structure essential for mobility, providing stability, flexibility, and load transmission during functional activities like walking, running, and jumping. It comprises three key articulations: the talocrural joint (tibia, fibula, talus) responsible for dorsiflexion and plantarflexion [1]; the subtalar joint (talus, calcaneus) for inversion and eversion [2], and the transverse tarsal joint (talonavicular and calcaneocuboid), enhancing foot adaptability during gait [3]. Ligaments, tendons, and muscles work in concert to stabilize these joints, and injury to these structures can significantly impair lower limb biomechanics [4].

Lateral Ankle Sprains (LAS) are the most frequent musculoskeletal injuries, particularly in athletes [5]. LAS commonly results from an excessive inversion force on a plantarflexed foot during high-demand activities such as jumping, running, or sudden directional changes [6]. Epidemiological data estimate LAS incidence at approximately 1 per 10,000 people per day, with higher rates in adolescents, young adults, and females [7]. Sports like basketball, volleyball, and soccer report the highest prevalence [8]. Alarmingly, LAS carries a high recurrence rate—ranging from 30-70%—leading to Chronic Ankle Instability (CAI), marked by repeated episodes of "giving way," swelling, and persistent discomfort [9]. CAI is a risk factor for early-onset post-traumatic osteoarthritis, often necessitating surgical intervention [10].
LAS primarily involves damage to the Anterior Talofibular Ligament (ATFL), with more severe cases affecting the Calcaneofibular Ligament (CFL) and Posterior Talofibular Ligament (PTFL) [11]. Sprains are graded into three categories: Grade I: Ligament stretching without tearing; minor symptoms.
- Grade II: Partial ligament tear; moderate swelling, instability, and functional loss. - Grade III: Complete rupture with significant instability and dysfunction [12].

Damage to ligamentous mechanoreceptors leads to proprioceptive deficits and neuromuscular impairments, such as altered muscle activation and delayed peroneal reflexes [13]. Rehabilitation must target these neuromuscular deficits to prevent re-injury. Young female athletes are particularly vulnerable to ankle sprains due to anatomical factors (wider pelvis, increased Q-angle), hormonal influences (ligament laxity during certain menstrual phases), and neuromuscular deficits (poor balance, growth-related changes) [14]. Many receive inadequate rehabilitation, resulting in long-term performance limitations, compensatory movement patterns, psychological distress, and sports withdrawal [15]. Therefore, targeted interventions are urgently required. Rehabilitation strategies commonly employ Closed Kinetic Chain (CKC) and Open Kinetic Chain (OKC) exercises [16]. OKC exercises, where the distal limb segment moves freely, isolate specific muscles but may not replicate functional activities or provide sufficient joint stabilization [17]. CKC exercises, involving weight-bearing with a fixed distal segment, promote co-contraction of muscles around the ankle, improving proprioception and dynamic stability [18]. CKC more closely mimics athletic tasks like running and cutting [19].

Neurophysiologically, CKC exercises stimulate proprioceptive recovery more effectively than OKC, fostering cortical reorganization essential for regaining motor control [20]. Pain reduction, often assessed using the Visual Analog Scale (VAS) [21], and functional outcomes, measured via the Foot and Ankle Disability Index (FADI) [22], are crucial markers of rehabilitation success. While both CKC and OKC modalities offer benefits, comparative evidence regarding their effectiveness in young female athletes remains limited, necessitating further investigation.

2. NEED OF THE STUDY:

Ankle sprain is the most common injury occurring in sports. These injuries can lead to disability and can restrict the players from participating in sports. Thus, rehabilitation plays a major role in the management of ankle sprain.

Several studies have proven that physiotherapy is much effective in athletes with ankle sprain. There are evidences which also show the positive effects of conventional therapy, electrotherapy, manual therapy, mobilization and proprioceptive training etc.

There are very few studies conducted on closed chain VS open chain exercises in ankle sprain. Thus, need arises to compare the efficacy closed chain exercises versus open chain exercises combined with cryotherapy on pain and foot function among young female athletes with ankle sprain.

Hence the purpose of current study is to evaluate the efficacy closed chain exercises versus open chain exercises combined with cryotherapy on pain and foot function among young female athletes with ankle sprain.

3. OBJECTIVES OF STUDY:

There is a significant improvement in pain among young female athletes with ankle sprain with closed chain exercises.

There is a significant improvement on foot function among young female athletes with ankle sprain with closed chain exercises.

There is a significant improvement in pain among young female athletes with ankle sprain with open chain exercises.

There is a significant improvement on foot function among young female athletes with ankle sprain with open chain exercises.

There is no significant improvement in pain among young female athletes with ankle sprain with closed chain exercises.

There is no significant improvement on foot function among young female athletes with ankle sprain with closed chain exercises.

There is no significant improvement in pain among young female athletes with ankle sprain with open chain exercises.

There is no significant improvement on foot function among young female athletes with ankle sprain with open chain exercises.

4. AIM OF STUDY:

The aim of the study is to analyse the effect of closed chain exercises versus open chain exercises on pain and foot function among young female athletes with ankle sprain.

5. RESEARCH HYPOTHESIS:

Experimental Hypothesis: there may be significant difference between Closed chain exercises and Open chain exercises in improving pain and function among young female athletes with ankle sprain.

Null Hypothesis: There may not be significant difference between Closed chain exercises and Open chain exercises in improving pain and function among young female athletes with ankle sprain.

6. REVIEW OF LITERATURE:

Haifang wang et al (April 2021) conducted study on Comparison of the Effect of Resistance and Balance Training on Isokinetic Eversion Strength, Dynamic Balance, Hop Test, and Ankle Score in Ankle Sprain. This study was concluded that in patients with ankle sprains, 6 weeks of RT and BT improved eversion strength, lower extremity hop function, and subjective assessment. Moreover, BT was more effective than RT in improving the dynamic balance, results of the crossover hop test, conferring pain relief, and return to sporting activities. Therefore, BT rather than RT should be emphasized to provide pain relief and restore function for the return to sporting activities.

Massimiliano Leighe, Emanuele Rava et al (2020) Translation, cross-cultural adaptation, reliability, and validation of the Italian version of the Foot and Ankle Disability Index (FADI) and concluded that, validation and cross- cultural adaptation of the Italian version of FADI questionnaire has been performed successfully and its use can be considered appropriate and suggested in Italian clinical practice.

S. J. Kachanathu, A. R. Hafez et al in their study entitled “Efficacy of Closed and Open Kinematic Chain Exercises on Ankle Sprain Rehabilitation” concluded that ankle sprain patient rehabilitation with both OKC and CKC exercises are effective, Although CKC exercise is may be a better choice than OKC exercise when we consider functional activities especially ADLs.

Farzin Halabchi et al (sept 2016) conducted study on the Prevalence of Selected Intrinsic Risk Factors for Ankle Sprain Among Elite Football and Basketball Players. This study was concluded that some intrinsic risk factors including ankle joint laxity, impaired single leg balance test and decreased ankle plantarflexion seem to be more prevalent in athletes with history of acute or recurrent LAS. More prospective studies are required for better recognition of intrinsic risk factors of ankle injuries.

Seong bum Hong, et al in their entitled “Effects of Closed-Sling Exercise on Muscle Activity and Balance; Football Club Player with Chronic Ankle Instability” study concluded that Sling exercise had a therapeutic effect on functional ankle instability, improving the stability of the muscles around the ankle joints, improving the stability of the muscles around the ankle joints, and the ability to proprioceptive of the ankle. That is, it is anticipated that this method can be presented as an effective rehabilitation method for the stability of the ankle joint and prevention of recurrence of the ankle joint.

7. MEHTODOLOGY:

This comparative study was conducted in the Department of Orthopedics Physiotherapy, Pacific Medical University. A total of 60 female participants, aged 18 to 25 years, diagnosed with Grade I or II acute or subacute ankle sprains were recruited using a convenient sampling method. All participants provided informed consent prior to participation.

Inclusion Criteria:

Female participants aged 18–25.

Diagnosed with Grade I or II ankle sprain by an orthopedic surgeon.

Acute and subacute ankle sprains.

Willingness to participate.

Exclusion Criteria:

Other musculoskeletal or neurological disorders.

Recent lower limb fractures (within 6 months).

Previous ankle surgeries (within the past 2 years).

Study Design and Procedure:

A total of 85 individuals were screened, and 68 were identified with ankle sprains. Among these, 60 participants met the inclusion criteria and were randomly divided into two groups:

Group A (Closed Chain Exercises): n=30

Group B (Open Chain Exercises): n=30

Intervention:

Both groups underwent supervised physiotherapy interventions 4 days per week for 6 weeks. Each session included exercises performed once daily under the guidance of a physiotherapist. Participants were also advised to apply ice therapy for 20 minutes, three times per day, for 4 days a week.

Group A – Closed Chain Exercise Protocol:

Week 1–2: Leg press with resistance bands, mini squats, isometric ankle exercises.

Week 3–4: Progression to full squats, lunges, and star excursion balance exercises.

Week 5: Mini squats and lunges on a BOSU ball (with support), continued agility training.

Week 6: Full squats and lunges on BOSU ball (without support), continued proprioceptive drills.

Group B – Open Chain Exercise Protocol:

Week 1–2: Active plantarflexion, dorsiflexion, inversion, and eversion without resistance progressing to moderate resistance bands.

Week 3–4: Progressive resistance ankle movements and figure-of-eight tracing in the air.

Week 5–6: Further progression in resistance and repetitions for all ankle movements.

Post-Intervention Assessment: After the **6-week intervention**, both groups were reassessed using the **FADI** and **VAS** to evaluate improvements in function and pain reduction. Data were analyzed statistically to compare the outcomes between closed and open chain exercise interventions.

After randomization, baseline (pre-post intervention) assessments were conducted using the following outcome measures:

Foot and Ankle Disability Index (FADI): FADI is a validated self-reported questionnaire assessing daily activity and sports-related foot and ankle function. It includes 26 items scored on a 5-point Likert scale, where higher scores indicate better function. The FADI is sensitive to clinical change and widely used in foot and ankle rehabilitation.

Visual Analog Scale (VAS) for Pain: The VAS is a 10-cm line representing pain intensity, from “no pain” to “worst imaginable pain.” It is a simple, reliable, and validated tool commonly used in both clinical and research settings.

8. DATA ANALYSIS AND STATISTICS:

The data was entered in excel and was carry forwarded for statistical analysis. The summary of data was taken using descriptive statistics for mean and average. All the subjects were assessed for Foot and Disability Index and Pain.

9. STATISTICAL TESTS:

The Kolmogorov- Smirnov test was used to determine the data is normally distributed.

The data was normally distributed so paired sample T was used to determine the differences within Group A.

The data was normally distributed so paired sample T was used to determine the differences within Group B.

The Independent Sample T test was used to compare the differences between the intergroup data.

Comparison	Test Used	Rationale
Group A (Pre vs Post) – FADI	Paired t-test	Same participants, two time points
Group A (Pre vs Post) – VAS	Paired t-test	Same participants, two time points
Group B (Pre vs Post) – FADI	Paired t-test	Same participants, two time points
Group B (Pre vs Post) – VAS	Paired t-test	Same participants, two time points
Group A vs B – FADI Improvement	Independent t-test	Two separate groups, comparing improvement
Group A vs B – VAS Reduction	Independent t-test	Two separate groups, comparing reduction

10. RESULT:

Key Findings – Within Group Results

Group	Variable	Mean Pre	Mean Post	Mean Change	p-value	Interpretation
A	FADI	58.73	75.53	+16.80	< 0.0001	Significant improvement in function
A	VAS	5.53	2.87	–2.67	< 0.0001	Significant reduction in pain
B	FADI	54.25	64.89	+10.64	< 0.0001	Significant improvement in function
B	VAS	5.68	4.32	–1.36	< 0.0001	Significant reduction in pain

Both groups showed statistically significant improvements in FADI and VAS after their respective interventions, indicating that both closed and open chain exercises are effective for ankle sprain rehabilitation.

Key Findings – Between Group Results

Outcome	Group A Mean Change	Group B Mean Change	p-value	Interpretation
FADI Improvement	+16.80	+10.64	< 0.0001	Group A significantly better functional improvement
VAS Reduction	–2.67	–1.36	< 0.0001	Group A significantly better pain reduction

When comparing the degree of improvement between the groups, Group A (Closed Chain Exercises) showed statistically and clinically superior outcomes in both function and pain relief than Group B (Open Chain Exercises).

Closed Chain Exercises resulted in greater functional recovery and more effective pain reduction than Open Chain Exercises. The results are statistically significant ($p < 0.0001$) across all outcome measures.

Clinical implication: Closed chain exercises should be preferred in rehabilitation protocols for young female athletes with ankle sprain to maximize recovery and pain relief.

This study compared the effectiveness of closed-kinetic chain (CKC) and open-kinetic chain (OKC) exercises in young female athletes with Grade I and II ankle sprains. Sixty participants were randomized into two groups and underwent six weeks of rehabilitation. Outcomes were assessed using the Foot and Ankle Disability Index (FADI) for function and the

Visual Analog Scale (VAS) for pain.

Both CKC and OKC groups showed statistically significant improvements. In the CKC group, the mean FADI score increased by 16.80 points (from 58.73 to 75.53; $p < 0.0001$), and the VAS score decreased by 2.67 points (from 5.53 to 2.87; $p < 0.0001$). The OKC group improved by 10.64 points in FADI (from 54.25 to 64.89; $p < 0.0001$) and experienced a 1.36-point reduction in VAS (from 5.68 to 4.32; $p < 0.0001$).

Between-group analysis revealed that CKC exercises led to significantly superior outcomes in both pain relief and functional recovery. The additional 6-point FADI gain in the CKC group exceeds the minimal detectable change, indicating meaningful clinical improvement. Pain reduction was nearly double in the CKC group compared to OKC.

The enhanced efficacy of CKC exercises aligns with current literature. CKC movements mimic functional sports activities, promote co-contraction of stabilizing muscles, and stimulate proprioceptive feedback crucial for joint stability. These benefits are especially relevant for young female athletes, who may have gender-specific neuromuscular and biomechanical characteristics influencing injury risk and recovery.

While CKC exercises demonstrated superior outcomes, OKC exercises remain valuable for early-stage rehabilitation, particularly when weight-bearing is contraindicated. A phased approach incorporating both methods may be optimal.

In conclusion, CKC exercises should be prioritized in ankle sprain rehabilitation programs for young female athletes due to their superior impact on pain reduction, proprioception, and functional recovery.

11. DISCUSSION:

This study compared the effectiveness of closed-kinetic chain (CKC) and open-kinetic chain (OKC) exercises in young female athletes with Grade I and II ankle sprains. Both interventions significantly improved pain and function. However, CKC exercises resulted in superior outcomes. The CKC group showed a 16.80-point improvement in FADI and a 2.67-point reduction in VAS, compared to 10.64-point FADI improvement and 1.36-point VAS reduction in the OKC group ($p < 0.0001$).

These findings align with existing literature, confirming that CKC exercises better mimic sports-specific tasks, promote joint stability through co-contraction, and enhance proprioceptive feedback. This is particularly important in young female athletes, who are more prone to proprioceptive deficits and recurrent sprains due to anatomical and neuromuscular differences.

The study supports using CKC exercises as the primary rehabilitation approach for ankle sprains. However, OKC exercises still play a role in early rehabilitation, especially when pain limits weight-bearing. A phased combination of both exercise types may optimize recovery.

Limitations include the short-term focus, lack of long-term follow-up, and the specific population studied, limiting generalizability. Despite this, the study provides strong evidence to prioritize CKC exercises for pain reduction and functional improvement in young female athletes with ankle sprains.

12. CONCLUSION:

In conclusion, this study provides compelling and statistically robust evidence that a rehabilitation program centred on closed-kinetic chain exercises is significantly more effective than one based on open-kinetic chain exercises for improving function and reducing pain in young female athletes recovering from ankle sprains. The superior outcomes in the CKC group are well-aligned with modern understandings of neurophysiology and biomechanics, emphasizing the importance of functional, weight-bearing tasks that restore proprioception and dynamic joint stability. These findings are strongly supported by a growing consensus in the literature, particularly recent reviews focusing on the unique needs of female athletes. While OKC exercises retain a role in the rehabilitation toolkit, this research provides clinicians with a strong, evidence-based rationale to prioritize CKC exercises as the cornerstone of treatment for this common and debilitating sports injury. By doing so, they can more effectively facilitate a safe return to sport, minimize the risk of chronic instability, and promote the long-term musculoskeletal health of the athletes under their care.

13. LIMITATIONS AND RECOMMENDATIONS:

This study provides valuable insights into ankle sprain rehabilitation but has several limitations. The findings are limited in generalizability due to the specific focus on 18–25-year-old female athletes with Grade I or II sprains, excluding other populations such as males, older adults, or those with chronic or severe injuries. The short-term follow-up (six weeks) limits understanding of long-term outcomes, such as re-injury rates or sustained functional improvements.

Additionally, the study did not evaluate the effectiveness of a combined rehabilitation approach, which is commonly used in clinical practice. Both open-chain (OKC) and closed-chain (CKC) interventions were compared separately, but no group utilized a phased or hybrid protocol. Another limitation is the reliance solely on subjective outcome measures (VAS and

FADI), without incorporating objective performance-based assessments like balance or strength tests. Furthermore, the lack of detailed exercise protocols regarding specific exercises, intensity, sets, repetitions, and progression criteria reduces the ability to replicate or standardize the interventions in future research.

Recommendations include conducting studies with broader populations, including males, older individuals, adolescents, and those with chronic ankle instability (CAI). Future research should incorporate long-term follow-up to monitor re-injury rates and functional retention. It is also recommended to evaluate combined or phased rehabilitation protocols integrating both OKC and CKC exercises. The use of objective performance assessments alongside patient-reported outcomes is crucial for a comprehensive evaluation. Lastly, future studies should provide detailed and standardized exercise protocols, comparing different CKC modalities to determine the most effective components for rehabilitation success.

REFERENCES

[1] Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation. 3rd ed. Elsevier; 2016.

[2] Standring S, ed. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2015.

[3] Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. J Athl Train. 2002;37(4):364–375.

[4] Riegger-Krugh C, LeVeau BF. Lateral ankle instability: concepts and treatment. J Orthop Sports Phys Ther. 1984;6(4):180–185.

[5] Brostrom L. Sprained ankles: VI. Surgical treatment of "chronic" ligament ruptures. Acta Chir Scand. 1966;132(5):551–565.

[6] Tiberio D. Pathomechanics of structural foot deformities. Phys Ther. 1988;68(12):1840–1849.

[7] Donatelli R. Biomechanics of the Foot and Ankle. 2nd ed. F.A. Davis Company; 1996.

[8] Lephart SM, et al. Proprioception and neuromuscular control in joint stability. Hum Kinetics. 2000.

[9] Fong DT, et al. A systematic review on ankle injury and ankle sprain in sports. Sports Med. 2007;37(1):73–94.

[10] Doherty C, et al. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis. Br J Sports Med. 2014;48(24):190–197.