

Effectiveness of Combined Open and Closed Kinetic Chain Exercise versus PNF Stretching on Pain and Functional Performance in Army-Aspirant Runners with Shin Splints: A Randomised Clinical Trial

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Abstract

Background: Medial tibial stress syndrome (MTSS), commonly referred to as shin splints, is a running-related overuse condition associated with pain and reduced lower-extremity function. Army-aspirant runners experience repetitive running and high training loads.

Aim: To compare combined open and closed-chain kinetic exercises with PNF stretching for pain and functional performance in army-aspirant runners with shin splints.

Methods: An experimental randomised clinical trial included 24 army-aspirant runners aged 18–25 years. Participants were allocated to Group A (combined OKC and CKC exercises, n=12) or Group B (PNF hold-relax stretching, n=12). Each intervention was delivered for 30 minutes, three times per week for two weeks. VAS and LEFS were assessed before and after treatment. We used Wilcoxon signed-rank and Mann–Whitney tests.

Results: Both groups showed significant within-group improvements. Group A VAS changed from 6.83 ± 1.40 to 3.83 ± 1.59 and LEFS from 54.67 ± 10.77 to 69.00 ± 8.89 . Group B VAS changed from 6.92 ± 1.00 to 4.67 ± 0.89 and LEFS from 54.92 ± 5.98 to 65.83 ± 3.07 . Post-treatment between-group differences were significant for VAS ($p=0.031$) and LEFS ($p=0.007$).

Conclusion: Both interventions were effective, but the combined kinetic-chain exercise group produced greater improvements in pain and functional performance.

Keywords: Medial Tibial Stress Syndrome, Shin Splints, Open Kinetic Chain, Closed Kinetic Chain, PNF Stretching, Army-Aspirant Runners, Pain, Functional Performance.

1. Introduction

Running is widely practised for fitness, sport, and military training; however, repetitive high-impact loading and sudden increases in training load can cause lower-extremity overuse injuries. Medial Tibial Stress Syndrome (MTSS), commonly known as shin splints, is characterised by pain along the medial or posteromedial tibia and affects approximately 5% to 35% of runners. ^[1, 2]

Runners, athletes, and military recruits are at increased risk of MTSS. Reported risk factors include a previous history of MTSS, limited running experience, increased body mass index, increased navicular drop and other lower-limb biomechanical characteristics. [2]

The condition is particularly relevant to army-aspirant runners, who are exposed to repetitive running, high training loads, and sudden increases in physical activity during training. MTSS is highly prevalent among military recruits, with reported incidence ranging from 35% to 56%. The pain associated with MTSS may interfere with running, training participation, and functional performance, making early management important in this population. [3]

MTSS is considered a condition related to repetitive mechanical loading of the tibia and surrounding tissues. Repeated loading may exceed the ability of the tissues to adapt, particularly when the physical demands of training increase faster than tissue adaptation. Current evidence suggests that MTSS is multifactorial and may involve bone stress, periosteal and musculotendinous structures, and altered mechanical loading rather than a single pathological mechanism. [2, 3]

Pain is the predominant symptom of shin splints. It is commonly located along the medial or posteromedial aspect of the lower leg and may initially occur during exercise and decrease with rest. With increasing severity, pain may begin earlier during activity, become more intense with continued exercise, and may interfere with walking or other functional activities. The musculature of the lower leg may have an important role in the development and persistence of shin splints. Muscle imbalance resulting from impaired flexibility of the calf muscles combined with decreased strength and endurance of the anterior tibial and deep posterior compartments may contribute to altered lower-limb loading. Therefore, rehabilitation should address the strength, endurance, and flexibility of the involved muscle groups as well as their antagonists. [4]

Because shin splints may affect running and lower-extremity function, physiotherapy-based exercise rehabilitation is an important component of management. Exercise interventions may aim to improve muscle strength, flexibility, neuromuscular control, lower-limb stability, and functional performance. Different exercise-based approaches, including strengthening and stretching, have therefore been investigated for individuals with shin splints and tibial stress-related conditions. [4, 6]

One such approach is kinetic chain exercise. Kinetic chain exercises consist of movement patterns involving coordinated activity of multiple muscle groups and can be classified into open kinetic chain (OKC) and closed kinetic chain (CKC) exercises. Open kinetic chain exercises involve movements in which the distal part of the limb is free to move in space, such as leg extensions, hamstring curls, calf pumps, and dorsiflexion exercises. They mainly allow targeted activation of specific muscle groups. [5] Closed kinetic chain exercises involve movements in which the distal part of the limb is fixed against a surface, such as squats, lunges, leg presses, and step-ups. They involve multiple muscle groups and joints and may improve strength, coordination, neuromuscular control, and joint stability. Therefore, combining OKC and CKC exercises may provide both specific muscle strengthening and functional weight-bearing training. [5]

Another physiotherapy approach used to improve muscle flexibility is Proprioceptive Neuromuscular Facilitation (PNF) stretching. PNF stretching integrates active muscle contractions into a stretching manoeuvre and is used to improve muscular flexibility and range of motion. Among the PNF techniques, the hold-relax technique is commonly used and involves an isometric contraction followed by relaxation and further stretching of the muscle. [7, 8]

Despite the use of strengthening and stretching approaches in shin-splint rehabilitation, there is limited direct evidence comparing combined OKC and CKC exercise with PNF stretching specifically in army-aspirant runners. Therefore, the present study was undertaken to compare the effects of these two interventions on pain and functional performance.

2. Aim and Objectives

Aim: To compare the effectiveness of combined open and closed kinetic chain exercises and proprioceptive neuromuscular facilitation (PNF) stretching in reducing pain and improving functional performance in army-aspirant runners with shin splints.

Objectives: (1) To assess the effect of combined open and closed kinetic chain exercises on pain reduction and improving functional performance using the VAS and LEFS scale. (2) To assess the effect of PNF stretching on pain reduction and improving functional performance using VAS and LEFS scale. (3) To compare the effect of combined open and closed kinetic chain exercises and PNF stretching on pain reduction and improving functional performance.

3. Materials and Methods

3.1 Study Design and Setting

An experimental randomised clinical trial was conducted in Jalgaon, Maharashtra, India. The study population consisted of army-aspirant runners. The total study duration was six months. Ethical clearance was obtained from the Institutional Ethical Committee of Dr Ulhas Patil College of Physiotherapy, Jalgaon.

3.2 Participants and Sample Size

A total of 24 participants were included, with 12 participants in Group A and 12 participants in Group B. Convenience sampling was used as a sampling method.

3.3 Eligibility Criteria

Inclusion criteria were age 18–25 years, both male and female participants, bilateral shin pain, symptoms for more than two weeks, and pain localised to the anterior and posteromedial aspects of the shin. Exclusion criteria were traumatic leg conditions, congenital deformities of the leg, lower-leg fractures, ankle sprain, infectious conditions of the leg and peripheral vascular disease.

3.4 Diagnostic Assessment and Outcome Measures

The shin palpation test was used as a clinical diagnostic criterion. Palpation was performed over the distal two-thirds of the posteromedial lower leg, including the posteromedial border of the tibia and associated musculature bilaterally. Pain reported during palpation was recorded as pain present [4].

Pain intensity was assessed using the Visual Analogue Scale (VAS), a 10-cm scale ranging from 0, representing no pain, to 10, representing very severe pain. Functional performance was assessed using the Lower Extremity Functional Scale (LEFS), consisting of 20 items scored from 0 to 4, with a maximum score of 80; higher scores indicate better function.

3.5 Procedure

After ethical clearance and written informed consent, demographic details were recorded and, the study was explained to participants. Participants were distributed into Group A and Group B. Baseline VAS and LEFS assessments were performed before treatment. The assigned interventions were administered for six sessions over two weeks. Post-treatment VAS and LEFS assessments were then performed. Data were entered into spreadsheet software and analysed using SPSS/JASP.

3.6 Intervention Protocol

Group A received combined OKC and CKC exercises. Each session lasted 30 minutes and was conducted three times per week for two weeks, giving six sessions. OKC exercises included hamstring curls (15 repetitions $\times$ 3 sets), calf pumps (15 repetitions $\times$ 3 sets), and seated knee extension from 90° flexion to 0° extension with a 5-second hold (15 repetitions $\times$ 3 sets). CKC exercises included mini-squats through approximately 30–60° knee flexion with a 10-second hold (10 repetitions), step-up and step-down exercises (10 repetitions), and lunges with a 10-second hold (10 repetitions).

Group B received PNF stretching using the hold-relax technique. Each session lasted 30 minutes and was conducted three times per week for two weeks. For the dorsiflexors, the ankle was positioned into plantar flexion until a mild stretch was felt over the anterior shin, followed by isometric dorsiflexion against resistance at approximately 50% of maximal strength. The contraction was held for 8 seconds followed by 10 seconds of relaxation, after which the limb was moved passively into the new range and stretched again. For the plantar flexors, the ankle was positioned into dorsiflexion until a mild stretch was felt along the medial/posteromedial lower leg, followed by isometric plantarflexion at approximately 50% of maximal strength, an 8-second hold, 10-second relaxation and subsequent passive stretching.

Intervention Protocol Summary

Group	Intervention	Dose / Details	Duration
A	Combined OKC + CKC	Hamstring curls 15 $\times$ 3; calf pumps 15 $\times$ 3; seated knee extension 15 $\times$ 3 with 5-sec hold; mini-squats 10 reps with 10-sec hold; step-up/step-down 10 reps; lunges 10 reps with 10-sec hold	30min/session; 3 $\times$ /week; 2 weeks (6 sessions)
B	PNF hold-relax	Dorsiflexors and plantar flexors; ~50% maximal isometric contraction, 8-sec hold, 10-sec relaxation, followed by passive stretch	30min/session; 3 $\times$ /week; 2 weeks (6 sessions)



Figure 1: Hamstring curl



Figure 2: Calf pumps



Figure 3: Seated leg extension



Figure 4: Mini-squats



Figure 5: Step-up and step-down



Figure 6: Lunges



Figure 7: PNF Stretching

4. Statistical Analysis

Continuous variables were summarised using mean and standard deviation, while categorical variables were summarized using frequency and percentage. Normality was assessed using the Shapiro–Wilk test. Because the outcome data did not consistently satisfy the normality assumption, non-parametric tests were used. Within-group pre- and post-treatment comparisons were performed using the Wilcoxon signed-rank test. Between-group comparisons were performed using the independent-samples Mann–Whitney test. Effect size was calculated using the standard correlation coefficient. Statistical significance was set at $p < 0.05$, with a 95% confidence level.

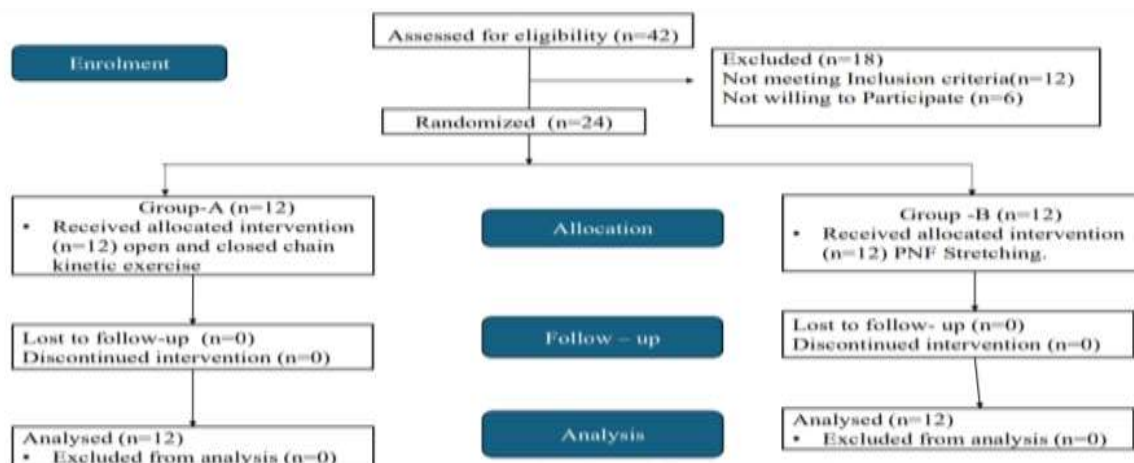


Figure 8: CONSORT chart

5. Results

The study included 24 participants, 12 in each group, aged 18–25 years. There were 13 female and 11 male participants. Group A included 7 females and 5 males, whereas Group B included 6 females and 6

males. The between-group gender distribution was not statistically significant ($\chi^2 = 0.168$, $p = 0.682$). Baseline VAS and LEFS scores were also comparable between groups.

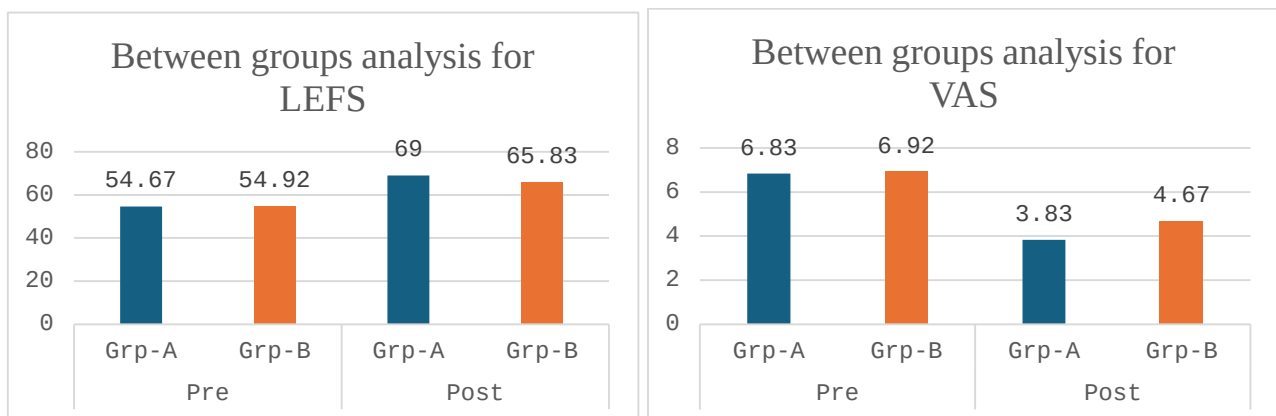
For VAS, Group A showed a reduction in mean score from 6.83 ± 1.40 at baseline to 3.83 ± 1.59 after treatment. The mean change was 3.00, with an effect size of 0.889 and $p = 0.001$. Group B showed a reduction from 6.92 ± 1.00 to 4.67 ± 0.89 , with a mean change of 2.25, effect size 0.897 and $p = 0.001$.

For LEFS, Group A improved from 54.67 ± 10.77 to 69.00 ± 8.89 , with a mean change of 14.33, effect size 0.885 and $p = 0.001$. Group B improved from 54.92 ± 5.98 to 65.83 ± 3.07 , with a mean change of 10.92, effect size 0.884 and $p = 0.001$.

Between-group analysis showed no significant baseline difference in VAS (Group A 6.83 ± 1.40 ; Group B 6.92 ± 1.00 ; test value 0.030; $p = 0.976$). Post-treatment VAS differed significantly between groups (Group A 3.83 ± 1.59 ; Group B 4.67 ± 0.89 ; test value 2.158; $p = 0.031$). For LEFS, baseline scores were not significantly different (Group A 54.67 ± 10.77 ; Group B 54.92 ± 5.98 ; test value 0.058; $p = 0.954$), while post-treatment scores differed significantly (Group A 69.00 ± 8.89 ; Group B 65.83 ± 3.07 ; test value 2.696; $p = 0.007$).

Outcome	Group	Pre Mean $\pm$ SD	Post Mean $\pm$ SD	Mean Change	p-value
VAS	A	6.83 ± 1.40	3.83 ± 1.59	3.00	0.001
VAS	B	6.92 ± 1.00	4.67 ± 0.89	2.25	0.001
LEFS	A	54.67 ± 10.77	69.00 ± 8.89	14.33	0.001
LEFS	B	54.92 ± 5.98	65.83 ± 3.07	10.92	0.001

Table 1: Pre- and Post-Treatment Outcome Measures



6. Discussion

The present study compared combined OKC and CKC exercises with PNF stretching in army-aspirant runners with shin splints. Both groups demonstrated statistically significant improvements in pain and functional performance after six treatment sessions over two weeks.

In Group A, pain decreased from 6.83 ± 1.40 to 3.83 ± 1.59 , with a mean reduction of 3.00 and $p = 0.001$. The improvement may be related to the combination of targeted muscle activation through OKC exercises and coordinated weight-bearing through CKC exercises. OKC exercises can facilitate specific strengthening, whereas CKC exercises involve multiple joints and muscle groups and may contribute to

lower-limb stability, coordination and functional loading. These changes may improve load distribution and tolerance to running-related demands. The result is consistent with Immanuel and Muthukrishnan (2025), who reported reduced pain following combined OKC and CKC exercise in football players with shin splints [7]. Evidence from other lower-limb rehabilitation populations also supports the use of kinetic-chain exercise for pain and functional improvement, although those populations differ from MTSS [6, 16]. Group A also demonstrated improvement in LEFS from 54.67 ± 10.77 to 69.00 ± 8.89 , with a mean increase of 14.33 and $p = 0.001$. The improvement may reflect the combined strengthening and functional weight-bearing components of the program. Mini-squats, step-ups and lunges require coordinated lower-limb control and may have greater functional similarity to activities required during running and training. The result is compatible with the findings of Immanuel and Muthukrishnan (2025) and with evidence that both OKC and CKC exercise can improve lower-limb function in other musculoskeletal conditions [6, 7]. Group B demonstrated a significant reduction in VAS from 6.92 ± 1.00 to 4.67 ± 0.89 , with a mean reduction of 2.25 and $p = 0.001$. The hold-relax PNF protocol may have contributed through muscle relaxation and improved extensibility following isometric contraction and relaxation. Ghanbari et al. reported that hold-relax PNF was effective in improving hamstring extensibility [8]. Sohail et al. also reported beneficial effects of PNF stretching on pain and lower-limb outcomes in runners with calf muscle delayed-onset muscle soreness [9]. Although DOMS is different from MTSS, the runner population and lower-limb application provide relevant supporting evidence.

Functional performance in Group B improved from 54.92 ± 5.98 to 65.83 ± 3.07 , with a mean increase of 10.92 and $p = 0.001$. Improved flexibility and reduced muscular tightness may facilitate lower-limb movement and make activities such as walking, running and stair climbing more comfortable. Stretching-based management has also been associated with improved pain and functional ability in athletes with shin splints, although the intervention used by Mandom and Paul differed from the PNF protocol used in the present study [11].

Between-group analysis showed significant differences after treatment for both VAS and LEFS. The combined kinetic-chain group had a lower post-treatment VAS score and a higher post-treatment LEFS score than the PNF group. The greater mean changes in Group A may reflect the broader intervention components of strengthening, weight-bearing, neuromuscular control and functional training, whereas the PNF protocol primarily emphasised flexibility and relaxation.

7. Conclusion

Both combined open and closed kinetic chain exercises and PNF stretching were associated with significant reductions in pain and improvements in functional performance in army-aspirant runners with shin splints. The combined kinetic-chain group demonstrated greater mean improvement in VAS and LEFS and significantly different post-treatment scores compared with the PNF group. The findings provide preliminary evidence supporting the use of a combined strengthening and functional exercise approach in this population, while larger studies with longer follow-up are required to establish the durability and generalizability of the findings.

8. Limitations

The study had no long-term follow-up to determine whether treatment effects were maintained. The sample size was small, and the study population and setting were limited to Jalgaon, which may restrict generalizability. Individual factors including physical fitness, training intensity, running experience and adherence to the intervention may also have influenced the outcomes.

9. Future Scope

Future studies should include larger samples and longer intervention and follow-up periods. Additional outcomes such as muscle strength, flexibility, balance and running biomechanics may provide a broader assessment of treatment effects. Similar comparisons may also be conducted in different runner and athlete populations.

10. Acknowledgement

I am deeply grateful to Dr Jaywant Nagulkar (PT), Principal of Dr Ulhas Patil College of Physiotherapy, Jalgaon, and Dr Pavan Chopade (PT), Assistant Professor and project guide, for their support and guidance. I also thank all the study participants for their active participation and the relevant authorities for their support.

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