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Effects of Extracorporeal Shockwave Therapy on Pain in Individuals with Medial Tibial Stress Syndrome

Dr. Rishita Priya
Research Scholar
Department of Physiotherapy People's University, Bhopal
Dr. Huma Khan
Professor
Department of Physiotherapy People's University, Bhopal
Dr. Mahima Masih
Assistant Professor
Department of Physiotherapy People's University, Bhopal

ABSTRACT
Background: Medial Tibial Stress Syndrome (MTSS) is a common overuse injury characterized by pain along the posteromedial border of the tibia. Extracorporeal Shockwave Therapy (ESWT) has been proposed as an effective non-invasive intervention for reducing pain and improving recovery. Objective: To evaluate the effectiveness of ESWT on pain in individuals with MTSS. Methods: A randomized controlled pre–post study was conducted on 30 participants, with 15 participants each in the experimental and control groups. The experimental group received ESWT along with conventional physiotherapy, whereas the control group received conventional management. Outcomes were assessed using the Numeric Pain Rating Scale (NPRS), Lower Extremity Functional Scale (LEFS), and MTSS score. Statistical significance was considered at $p<0.05$. Results: The experimental group demonstrated significant improvement in NPRS, LEFS, and MTSS scores following intervention ($p<0.001$). Post-treatment comparison between the experimental and control groups also showed significant differences in favour of the experimental group ($p<0.0001$). Conclusion: ESWT combined with conventional physiotherapy was effective in reducing pain and improving functional outcomes in individuals with MTSS and may be considered a useful adjunct in rehabilitation.
Keywords: Medial Tibial Stress Syndrome; ESWT; NPRS; LEFS; Physiotherapy

1. INTRODUCTION

Medial tibial stress syndrome (MTSS) is a common lower-extremity overuse injury, particularly among runners, athletes and military personnel. It commonly presents with diffuse pain and tenderness along the posteromedial border of the tibia, usually in the distal two-thirds, and is aggravated by physical activity. The condition is clinically important because recurrent symptoms can disrupt training, reduce performance and, when inadequately managed, may occur along a continuum of tibial stress injury.

The source study describes MTSS as a multifactorial condition involving both intrinsic and extrinsic risk factors. Relevant intrinsic factors include female sex, higher body mass index, increased navicular drop or pronated foot posture, altered hip and ankle mechanics, and reduced lower-leg muscle strength. Extrinsic contributors include rapid increases in training volume or intensity, hard training surfaces, inappropriate footwear and inadequate training progression [1–6].

The pathophysiology described in the study includes repetitive tibial loading, periosteal irritation, muscular microtrauma and a bone-stress response. Imaging, particularly MRI, may demonstrate periosteal edema, soft-tissue inflammation or marrow changes in selected cases. Conventional management typically includes relative rest, ice, analgesic or anti-inflammatory strategies, load modification, physiotherapy and correction of biomechanical deficits [7–10]. However, treatment response is variable and recurrence remains a challenge.

Extracorporeal shockwave therapy is a non-invasive modality that delivers mechanical pressure waves to target tissues. The study distinguishes focused and radial forms of ESWT and describes potential biological effects including mechanotransduction, stimulation of angiogenic pathways, activation of vascular endothelial growth factor and endothelial nitric oxide synthase, osteogenic responses, tissue remodeling and hyperstimulation analgesia [11–13]. These mechanisms provide a rationale for its use in an overuse condition involving both soft tissue and bone-stress responses.

Recent literature summarized in the study indicates that ESWT has shown benefit across several musculoskeletal conditions, while MTSS-specific evidence remains heterogeneous. Some studies support shockwave therapy as an adjunct to exercise, orthoses and multimodal rehabilitation, whereas systematic reviews have noted variability in protocols and limited high-quality evidence [14–18]. The present study therefore compared ESWT plus conventional rehabilitation with conventional management alone in individuals with MTSS.

1.1 Aim and Objectives

Aim: To evaluate the effectiveness of extracorporeal shockwave therapy on pain reduction in individuals with medial tibial stress syndrome.

1. To evaluate pain levels using standardized pain measurement scales in both intervention and control groups.
2. To determine the efficacy of ESWT in accelerating recovery and improving tissue healing.
3. To compare pain reduction outcomes between ESWT combined with exercise and exercise alone.

1.2 Hypostudy

The null hypostudy stated that there would be no significant effect of extracorporeal shockwave therapy on pain in individuals with medial tibial stress syndrome. The alternative hypostudy stated that a significant effect would be present.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

The study is described as a randomized controlled trial with pre- and post-intervention assessment. Participants were recruited from individuals diagnosed with medial tibial stress syndrome and seeking treatment at People's Hospital. The Methods section states that 30 participants were enrolled and allocated to an Experimental Group (ESWT + exercise) or a Control Group (conventional management), with 15 participants in each group.

2.2 Participant Selection

Inclusion criteria were:

- Age 18–45 years.
- Confirmed diagnosis of medial tibial stress syndrome based on clinical examination and symptom presentation.
- Pain localized to the distal two-thirds of the medial tibial border.
- Willingness to complete the treatment protocol and follow-up assessment.

Exclusion criteria included:

- History of tibial stress fracture or confirmed stress fracture on imaging.
- Compartment syndrome or signs of compartment involvement.
- Previous ESWT treatment for lower-extremity conditions.
- Systemic bone disease or metabolic disorder affecting bone healing.
- Pregnancy or breastfeeding.
- Active malignancy/history of cancer, severe cardiovascular disease or uncontrolled hypertension.
- Anticoagulant therapy or bleeding disorder.

2.3 Outcome Measures

Pain was measured using the Numeric Pain Rating Scale (NPRS), ranging from 0 (no pain) to 10 (worst pain). Functional status was assessed using the Lower Extremity Functional Scale (LEFS), a 20-item patient-reported measure scored from 0 to 80, with higher scores representing better lower-extremity function. The MTSS symptom score was also recorded to assess changes in symptoms following intervention.

2.4 Experimental Group: ESWT + Conventional Physiotherapy

The experimental group received focused extracorporeal shockwave therapy in combination with conventional physiotherapy and a structured exercise programme. ESWT was administered once weekly for five consecutive weeks. The reported treatment parameters were an energy flux density of 0.20 mJ/mm², adjusted according to tolerance, a frequency of 4 Hz and 2000–2500 impulses per session. Each ESWT session lasted approximately 15–20 minutes and was applied to the symptomatic medial tibial region, approximately 3–5 cm in length, using coupling gel.

The accompanying exercise programme included gastrocnemius and soleus stretching, resisted tibialis anterior dorsiflexion, heel raises, toe walking, heel walking and single-leg balance training with progression according to tolerance.

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2.5 Control Group

The control group received therapeutic ultrasound over the painful medial tibial region and the same general conventional exercise components described in the study. Ultrasound was reported at 1 MHz with an intensity of 1–1.5 W/cm². Exercises included gastrocnemius and soleus stretching, resisted dorsiflexion, heel raises, toe walking, heel walking and single-leg balance training.

2.6 Intervention Photographs

Intervention Photographs was carried out during the intervention sessions to demonstrate the treatment procedures and exercises performed as part of the study protocol. The following photographs illustrate the practical application of the interventions administered to the participants.

Image 1. Application of Extracorporeal Shockwave Therapy (ESWT)

Image 2. Therapeutic Exercise Performed During the Rehabilitation Programm

Image 3. Treatment/Exercise Procedure During the Study Intervention

2.7 Statistical Analysis

Descriptive statistics were used to summarize the study data and were expressed as mean and standard deviation. Between-group comparisons of the experimental and control groups were performed using an independent t-test, while within-group comparisons between pre- and post-intervention scores were performed using a paired t-test. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

The results of the study were analysed to determine the effectiveness of Extracorporeal Shockwave Therapy (ESWT) in individuals with Medial Tibial Stress Syndrome (MTSS). The experimental and control groups were compared using NPRS, LEFS, and MTSS scores. Between-group comparisons were performed using the independent t-test, whereas pre- and post-treatment comparisons within each group were performed using the paired t-test. A p-value of less than 0.05 was considered statistically significant.

3.1 Comparison Between Experimental and Control Groups

The experimental and control groups were compared for pre- and post-treatment NPRS, LEFS, and MTSS scores. At baseline, the groups showed comparable values for the measured outcomes. Following treatment, greater improvement was observed in the experimental group compared with the control group.

Table 1. Comparison Between Experimental and Control Groups in Different Scores

Score	Experimental Group Mean ± SD	Control Group Mean ± SD	Independent t-test	df	p-value	Result
Pre NPRS	7.1 ± 0.87	6.8 ± 1.03	0.7036	18	0.4907	Insignificant
Post NPRS	2.3 ± 0.67	5.7 ± 1.59	6.2315	18	<0.0001	Significant

Pre LEFS	40.0 ± 2.58	40.4 ± 1.71	0.4087	18	0.6876	Insignificant
Post LEFS	68.0 ± 2.58	41.5 ± 1.71	27.0740	18	<0.0001	Significant
Pre MTSS	7.0 ± 0.81	6.6 ± 1.17	0.8889	18	0.3858	Insignificant
Post MTSS	3.3 ± 0.67	5.8 ± 1.23	5.3945	18	<0.0001	Significant

The pre-treatment NPRS score did not differ significantly between the experimental and control groups (p=0.4907), whereas a statistically significant difference was observed in post-treatment NPRS scores (p<0.0001).
Similarly, no statistically significant difference was observed between the groups in pre-treatment LEFS scores (p=0.6876), whereas the post-treatment LEFS comparison showed a statistically significant difference (p<0.0001).
The pre-treatment MTSS scores were also comparable between the two groups (p=0.3858). However, a statistically significant difference was observed in post-treatment MTSS scores (p<0.0001).
Overall, the post-treatment findings showed greater improvement in the experimental group. Pain and MTSS scores decreased, while lower-extremity functional status, represented by the LEFS score, improved following the experimental intervention.

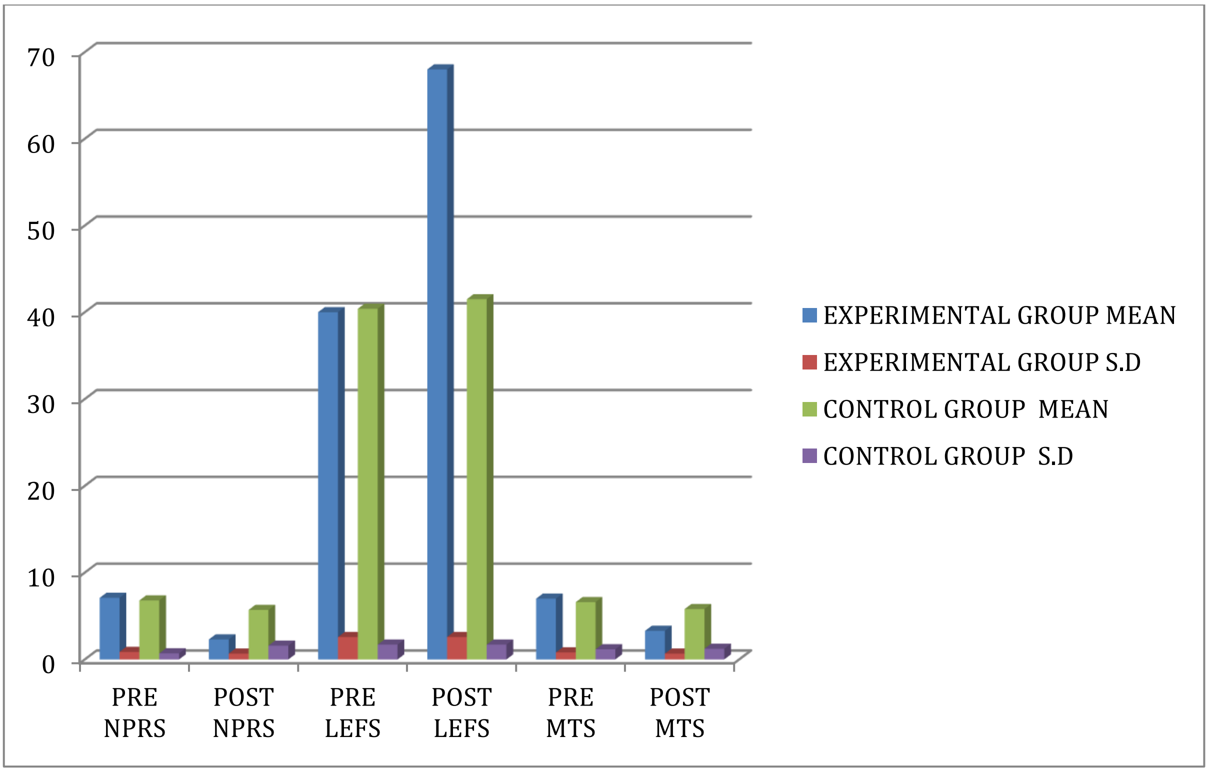

Figure 1. Comparison Between Experimental and Control Groups in Different Scores

3.2 Pre–Post Comparison in the Experimental Group

Pre- and post-treatment NPRS, LEFS, and MTSS scores were compared within the experimental group using the paired t-test. Significant changes were observed in all three outcome measures following the intervention.

Table 2. Comparison Between Pre- and Post-Test NPRS, LEFS, and MTSS Scores in the Experimental Group

Outcome	Pre-test Mean ± SD	Post-test Mean ± SD	Paired t-test	df	p-value	Result
NPRS Score	7.20 ± 0.92	2.30 ± 0.67	27.2972	9	<0.001	Significant
LEFS Score	40.00 ± 2.58	67.10 ± 4.56	28.5836	9	<0.001	Significant
MTSS Score	7.00 ± 0.82	3.30 ± 0.67	17.3353	9	<0.001	Significant

The NPRS score decreased from 7.20±0.92 before treatment to 2.30±0.67 after treatment, demonstrating a significant reduction in pain ($p<0.001$).

The mean LEFS score increased from 40.00±2.58 to 67.10±4.56 after the intervention, indicating improvement in lower-extremity functional ability. The difference was statistically significant ($p<0.001$).

The MTSS score decreased from 7.00±0.82 at pre-test to 3.30±0.67 at post-test, and the change was also statistically significant ($p<0.001$).

Therefore, the experimental group demonstrated statistically significant improvement in pain, functional status, and MTSS scores following the intervention.

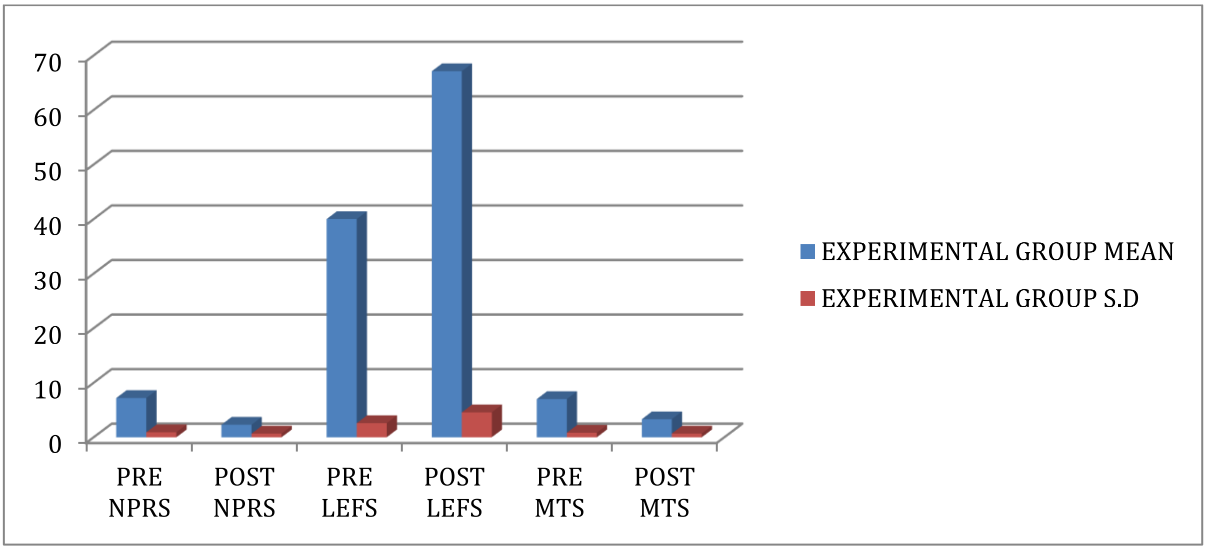

Figure 2. Comparison Between Pre- and Post-Test NPRS, LEFS, and MTSS Scores in the Experimental Group

3.3 Pre–Post Comparison in the Control Group

Pre- and post-treatment NPRS, LEFS, and MTSS scores were also compared within the control group using the paired t-test. The values obtained for the control group are presented in Table 3.

Table 3. Comparison Between Pre- and Post-Test NPRS, LEFS, and MTSS Scores in the Control Group

Outcome	Pre-test Mean ± SD	Post-test Mean ± SD	Paired t-test	df	p-value	Result
NPRS Score	6.80 ± 1.03	5.70 ± 1.16	6.1279	9	0.0002	Insignificant
LEFS Score	40.40 ± 1.71	41.50 ± 1.72	2.9055	9	0.0174	Insignificant
MTSS Score	5.60 ± 1.17	5.60 ± 1.17	4.0000	14	0.0174	Insignificant

The NPRS mean score decreased from 6.80±1.03 at pre-test to 5.70±1.16 at post-test. The LEFS mean score showed a small increase from 40.40±1.71 to 41.50±1.72. The MTSS mean score was reported as 5.60±1.17 at both pre- and post-treatment assessments.

Compared with the marked changes observed in the experimental group, the control group demonstrated comparatively limited changes in the measured outcomes. The findings therefore indicate a greater treatment response in the experimental group following ESWT combined with conventional physiotherapy.

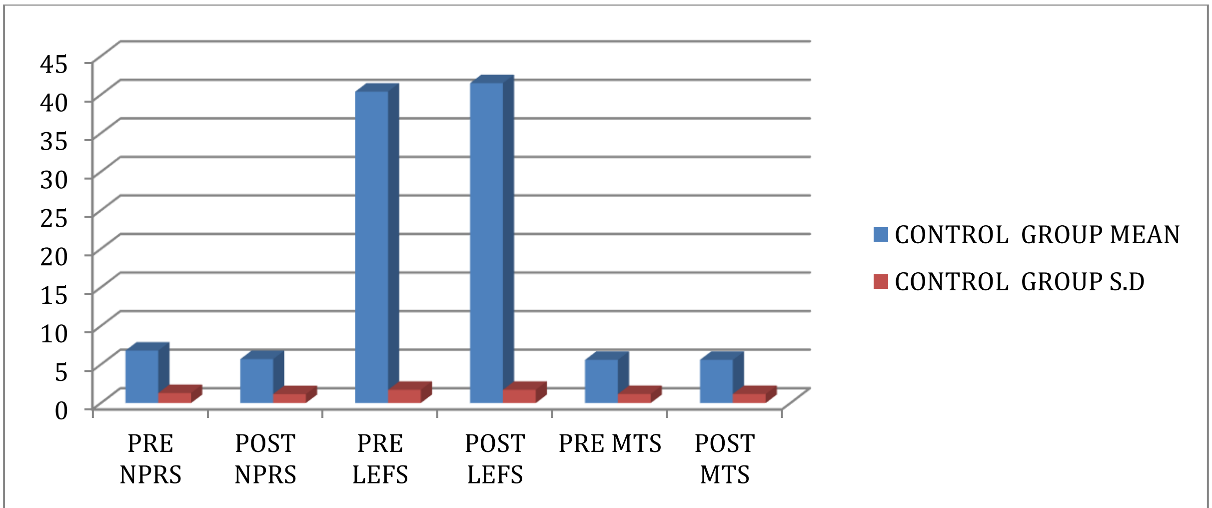

Figure 3. Comparison Between Pre- and Post-Test NPRS, LEFS, and MTSS Scores in the Control Group

4. DISCUSSION

The present study evaluated the effects of Extracorporeal Shockwave Therapy (ESWT) on pain and functional outcomes in individuals with Medial Tibial Stress Syndrome (MTSS). The findings demonstrated greater improvement in the experimental group receiving ESWT in combination with conventional physiotherapy compared with the control group.

The experimental group showed a marked reduction in NPRS scores following treatment, indicating improvement in pain intensity. Functional ability also improved, as demonstrated by the increase in LEFS scores. In addition, improvement was observed in MTSS scores following the intervention. The between-group findings further demonstrated greater post-treatment improvement in the experimental group compared with the control group.

The findings of the present study are consistent with a growing body of literature supporting the effectiveness of Extracorporeal Shockwave Therapy in the management of MTSS and other overuse injuries.

Moen MH et al. (2012), in the study titled *"The Treatment of Medial Tibial Stress Syndrome in Athletes: A Randomized Clinical Trial,"* reported that athletes treated with ESWT in combination with a graded running programme demonstrated faster recovery compared with those receiving exercise therapy alone. These findings are consistent with the present study, in which the experimental group demonstrated greater reduction in pain following intervention.

Similarly, Rompe JD et al. (2010), in their study *"Effectiveness of Extracorporeal Shock Wave Therapy for Chronic Musculoskeletal Conditions,"* reported that ESWT reduced pain and improved functional outcomes among patients with chronic overuse injuries. These findings support the improvement in pain and lower-extremity function observed in the experimental group of the present study.

Newman P et al. (2013), in *"Medial Tibial Stress Syndrome: Conservative Treatment Options and Outcomes,"* emphasized the role of conventional approaches such as rest, stretching, and strengthening exercises in MTSS management. The study further indicated that adjunct therapeutic modalities such as ESWT may contribute to enhanced recovery and faster symptom resolution. This corresponds with the present study, in which ESWT was administered together with conventional physiotherapy and a structured exercise programme.

Winters M et al. (2013), in a systematic review titled *"Treatment of Medial Tibial Stress Syndrome: A Systematic Review,"* reported promising findings regarding ESWT compared with conservative modalities such as ultrasound therapy, laser therapy, and rest. The findings suggested that ESWT may facilitate recovery, which is consistent with the greater improvement observed in the experimental group of the present study.

Vulpiani MC et al. (2009), in *"Extracorporeal Shock Wave Therapy in the Treatment of Chronic Tendinopathies,"* reported that ESWT may promote tissue regeneration and contribute to pain reduction in chronic musculoskeletal conditions. These effects provide support for the improvement observed following ESWT in the present study.

Speed CA et al. (2002), in *"Extracorporeal Shock-Wave Therapy for Tendinopathy: A Review,"* also suggested a beneficial effect of ESWT on pain reduction. However, the authors highlighted that treatment outcomes may vary according to treatment parameters. This emphasizes the importance of appropriate dosage and application of ESWT in achieving therapeutic effects.

Contradictory findings have also been reported. Rue JP et al. (2004), in the study *"The Effect of Extracorporeal Shock Wave Therapy on Medial Tibial Stress Syndrome: A Randomized Controlled Trial,"* reported no significant difference between ESWT and placebo treatment. Differences between studies may be related to variations in sample characteristics, sample size, intervention protocols, treatment parameters, and severity of MTSS.

In the present study, ESWT was used together with conventional physiotherapy, including gastrocnemius and soleus stretching, resisted tibialis anterior dorsiflexion, heel raises, toe walking, heel walking, and balance training. The combined approach may have contributed to the improvement in pain and functional outcomes observed in the experimental group.

Overall, the findings of the present study support the use of ESWT in combination with conventional physiotherapy for the management of individuals with Medial Tibial Stress Syndrome. The experimental group demonstrated greater improvement in pain and functional outcomes compared with the control group, suggesting that ESWT may provide additional therapeutic benefit when incorporated into a structured rehabilitation programme.

5. CLINICAL IMPLICATIONS

- ESWT may be considered as an adjunct to conventional rehabilitation for patients with MTSS who require additional pain-management and recovery strategies.
- Combining ESWT with stretching, strengthening and balance training may address both symptoms and modifiable biomechanical contributors.
- The reported protocol provides a reproducible starting framework: focused ESWT once weekly for five weeks, 2000–2500 impulses, 4 Hz and approximately 0.20 mJ/mm^2 adjusted to tolerance.
- Clinicians should individualize shockwave parameters according to patient tolerance, tissue irritability and relevant contraindications.
- Long-term return-to-running or return-to-activity planning should include progressive loading and correction of training errors in addition to symptom treatment.

6. LIMITATIONS

- The present study has certain limitations that should be considered while interpreting the findings. The relatively small sample size may limit the generalizability of the results to the wider population of individuals with Medial Tibial Stress Syndrome.
- Variations in the application of Extracorporeal Shockwave Therapy, including differences in intensity, frequency, treatment technique, and individual tolerance, may influence treatment outcomes and may affect the reproducibility of the intervention.
- The study relied mainly on patient-reported outcome measures such as pain and functional assessment scales. Such measures may be influenced by participants' perceptions, expectations, and individual responses to treatment.

- Medial Tibial Stress Syndrome is a multifactorial condition that may be associated with overuse, biomechanical abnormalities, training errors, physical activity levels, and other individual factors. These factors were not separately analysed in the present study and may have influenced treatment outcomes.
- Long-term follow-up was not included, limiting the ability to determine whether the improvements observed following the intervention were maintained over an extended period. Other potential confounding variables, including participants' activity levels, previous treatment history, and associated physical factors, may also have influenced the findings.

7. CONCLUSION

The present study evaluated the effects of Extracorporeal Shockwave Therapy on pain and functional outcomes in individuals with Medial Tibial Stress Syndrome. The findings demonstrated that participants receiving ESWT in combination with conventional physiotherapy showed greater improvement in pain, lower-extremity functional ability, and MTSS scores following treatment.

The experimental group demonstrated significant improvement in NPRS, LEFS, and MTSS outcomes after the intervention, while the post-treatment comparison between the experimental and control groups favoured the experimental intervention. These findings indicate that the addition of ESWT to a structured conventional physiotherapy programme may provide additional therapeutic benefit in the management of Medial Tibial Stress Syndrome.

Therefore, Extracorporeal Shockwave Therapy may be considered a useful adjunct to conventional physiotherapy for reducing pain and improving functional outcomes in individuals with MTSS. Further studies involving larger sample sizes, standardized ESWT protocols, and longer follow-up periods are recommended to evaluate the long-term effectiveness of the intervention.

8. DIRECTIONS FOR FUTURE RESEARCH

- Conduct larger randomized trials with clearly documented participant flow and analysed sample size.
- Use standardized ESWT parameters and report device type, energy flux density, impulse number and session frequency consistently.
- Include longer follow-up to evaluate recurrence, return to sport/activity and durability of pain relief.
- Investigate whether specific biomechanical subgroups respond differently to ESWT.
- Compare ESWT plus exercise with exercise alone using verified raw data and prespecified primary outcomes.
- Report clinically interpretable effect sizes and confidence intervals in addition to p-values.

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