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Comparative Effects of Fascial Distortion Model and Foam Rolling on Pain, Calf Flexibility and Ankle Range of Motion Among High Heel Users: A Randomized Clinical Trial

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ABSTRACT

Background: Prolonged high-heel use is associated with calf muscle tightness, reduced ankle dorsiflexion, and pain, leading to functional limitations. Effective interventions such as the Fascial Distortion Model (FDM) and foam rolling are increasingly used in musculoskeletal rehabilitation, but their comparative efficacy remains unclear.

Objective: To evaluate and compare the effects of FDM and foam rolling on pain, ankle dorsiflexion range of motion (ROM), and functional performance among habitual high-heel users.

Methods: A randomized clinical trial was conducted with 30 female participants (age 18–26 years; BMI 21–37 kg/m²). Participants were randomly assigned to either the FDM group (n=15) receiving manual therapy (Trigger Band and Cylinder Distortion techniques) or the foam rolling group (n=15). Both interventions were administered twice weekly for 4 weeks, following a standardized baseline calf stretching protocol. Pain was assessed with the Numerical Pain Rating Scale (NPRS), ankle ROM with a goniometer, and functional dorsiflexion with the Weight-Bearing Lunge Test (WBLT).

Results: Among Both interventions produced significant improvements across time points ($p<0.001$). At week 4, foam rolling showed superior outcomes compared to FDM: NPRS (3.80±0.77 vs. 4.40±0.73), ROM (18.60±1.05 vs. 14.20±1.52), and WBLT (16.36±0.21 vs. 10.22±0.70). Between-group differences were statistically significant ($p<0.05$).

Conclusion: Increased FDM and foam rolling are both effective in reducing calf-related pain and enhancing ankle dorsiflexion among habitual high-heel users. Foam rolling, however, demonstrated greater improvements in pain reduction, ROM, and functional performance, supporting its use as a practical and effective intervention in clinical and athletic settings.

Keywords: Ankle Dorsiflexion, Fascial Distortion Model, Foam Rolling, Gait, Footwear, Rehabilitation, Myofascial Release, Pain Management, Range Of Motion, Weight-Bearing Lunge Test

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Introduction

The Pain is a multifaceted experience that encompasses both sensory and emotional dimensions and is closely associated with tissue inflammation. It has been defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage (1). In sports and rehabilitation settings, increasing the range of motion (ROM) through stretching is widely practiced. While stretching is known to enhance flexibility, research presents conflicting findings regarding its acute effects on muscular strength (2).

Anatomically, the calf muscle particularly the gastrocnemius along with the quadriceps and hamstrings, plays a critical role in knee function due to their anatomical attachment to the knee joint (3). Flexibility in the calf muscles is thus essential for functional movement, however there is currently no established normative range for calf flexibility in a weight-bearing position (4). Stretching various muscle groups around the hip and knee joints has demonstrated performance benefits, suggesting that improving calf muscle flexibility may offer significant advantages to athletes, such as soccer players (5).

Pain, tenderness, stiffness, inflammation, reduced strength, and limited ROM are common consequences of muscular dysfunction (6). In recent years, manual therapy particularly the Fascial Distortion Model (FDM) has gained popularity among clinicians and rehabilitation specialists for treating orthopedic and trauma-related conditions (7). Increased muscular flexibility, or muscle extensibility, has been positively correlated with enhanced joint mobility, which contributes to better performance and reduced injury risk (8).

Limited ankle dorsiflexion, often due to calf tightness, has been linked to altered lower limb biomechanics. These changes can compromise athletic performance and place excessive stress on surrounding connective tissues, potentially resulting in injury (9). The promotion of regular physical activity for health, recreation, and prevention of cardiovascular diseases has gained momentum globally, as evidenced by the Hong Kong Sports Institute's recent findings on rising participation across all age groups (10).

Extended use of high-heeled footwear is known to cause calf muscle tightness, which restricts ankle ROM. Various interventions have been proposed to address this issue, including foam rolling and FDM techniques. However, limited comparative data exists regarding their effectiveness in improving calf flexibility, ankle ROM, and alleviating pain among habitual high-heel users. Therefore, this study aims to evaluate and compare the effects of the Fascial Distortion Model and foam rolling on these parameters.

Materials and Methods

This study was conducted as a randomized clinical trial involving a total of 30 female participants. Participants were selected using a convenience sampling technique from Government College University, Faisalabad, and the University of Agriculture, Faisalabad. The study was carried out over a period of four months following formal approval of the research synopsis.

Inclusion criteria required participants to be females aged between 18 and 30 years who regularly wore high heels with a heel height ranging from 2 to 4 cm. Participants were required to have a history of wearing heels for more than one year, with usage exceeding four days per week and lasting 5 to 7 hours per day. Additionally, eligible participants reported experiencing pain in the lower calf area, particularly in the gastrocnemius and soleus muscles, sometimes radiating to the Achilles tendon or the heel (11).

Exclusion criteria included individuals with excessive body weight, recent ankle sprains or calf muscle strains, fractures of the lower extremities, or recent injuries to the ankle. Women who were pregnant or used walking aids were excluded, as were those with congenital lower limb abnormalities or diagnosed lower extremity pathologies. Participants with spinal postural deformities such as scoliosis or kyphosis, metabolic disorders including hypothyroidism, hyperthyroidism, or Cushing's syndrome, and those with psychological or psychiatric conditions were also excluded. Lastly, individuals who had undergone any form of physical therapy treatment within the past four to six weeks were not considered for participation.

Informed consent was obtained from all participants after they were briefed on the purpose and procedures of the study. The treatment protocol centered around calf muscle self-stretching, which formed the basis of both intervention arms. Pain levels were measured using the Numerical Pain Rating Scale (NPRS) (12). Calf flexibility was assessed through the Weight-Bearing Lunge Test (WBLT) (13), while ankle range of motion (ROM) was measured using a goniometer (14).

Participants were randomly divided into two groups of 15 individuals each. Group A received baseline treatment followed by manual therapy using the Fascial Distortion Model (FDM), which incorporated two specific techniques: Trigger Band and Cylinder Distortion. Group B also received the same baseline treatment but followed it with a foam rolling intervention targeting the calf muscles. The intervention lasted for a total of four weeks, with both groups receiving their respective treatments twice per week. Each intervention session lasted approximately five minutes (15).

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Results

A total of 30 participants (aged 18–26 years) were included in this study. The most frequently represented age was 22 years, accounting for 23.3% (n = 7). BMI values ranged from 21.00 to 37.00, with relatively even distribution across the sample. The most frequent BMI was 32.00 (13.3%), followed by 24.00 (10%) and 27.00 (10%). Both groups demonstrated significant reductions in pain intensity across the three time points ($p < 0.001$, Friedman test). Post-hoc comparisons revealed that while both interventions effectively reduced pain from baseline to 4 weeks, the Foam Rolling group achieved a greater reduction at the final follow-up (mean 3.80 ± 0.77) compared to the FDM group (mean 4.40 ± 0.73). These findings suggest that Foam Rolling provided slightly superior pain relief over time.

Table 1: Age and Body Mass Index (BMI) Distribution of Participants

Variable	Mean	SD	Range	Mode
Age (years)	22.6	2.21	18–26	22
BMI (kg/m²)	30.2	4.37	21–37	32

There was a significant improvement in ankle dorsiflexion ROM in both groups ($p < 0.001$). At 2 weeks, participants in the Foam Rolling group already demonstrated greater gains (13.40 ± 1.21) compared to the FDM group (11.46 ± 1.92). By 4 weeks, this difference widened, with Foam Rolling showing markedly higher dorsiflexion ROM (18.60 ± 1.05) relative to FDM (14.20 ± 1.52). Post-hoc analysis confirmed that the improvements in Foam Rolling were significantly greater at both 2 and 4 weeks ($p < 0.05$). Functional dorsiflexion measured by the Weight-Bearing Lunge Test (WBLT) also improved significantly in both groups ($p < 0.001$). At baseline, the FDM group (7.78 ± 0.40) scored slightly higher than Foam Rolling (6.59 ± 0.40). However, Foam Rolling demonstrated a substantially greater improvement by week 2 (11.64 ± 0.63 vs. 8.65 ± 0.54) and week 4 (16.36 ± 0.21 vs. 10.22 ± 0.70), with between-group differences reaching statistical significance ($p < 0.05$). This indicates superior effectiveness of Foam Rolling in restoring functional dorsiflexion.

Table 2: Comparison of FDM and Foam Rolling groups Across Time Points

Outcome	Time Point	FDM Group	Foam Rolling Group	p-value
Numerical Pain Rating Scale (NPRS)	Baseline	7.40± 0.91	7.60 ± 0.82	p < 0.001
	2 Weeks	5.73 ± 0.88	5.66 ± 0.72	
	4 Weeks	4.40 ± 0.73	3.80 ± 0.77	
Range of Motion (ROM)	Baseline	9.0 ± 1.81	8.40 ± 1.29	p < 0.001
	2 Weeks	11.46 ± 1.92	13.40 ± 1.21	
	4 Weeks	14.20 ± 1.52	18.60 ± 1.05	
Weight-Bearing Lunge Test (WBLT)	Baseline	7.78 ± 0.40	6.59 ± 0.40	p < 0.001
	2 Weeks	8.65 ± 0.54	11.64 ± 0.63	
	4 Weeks	10.22 ± 0.70	16.36 ± 0.21	

A Friedman test was conducted to analyze the progression of outcomes across the three time points. The results showed a consistent trend of improvement in all variables. For NPRS, the mean score decreased from 7.50 (SD = 0.87) at baseline to 5.70 (SD = 0.80) after two weeks, and further to 4.10 (SD = 0.75) after four weeks. For ROM, the mean improved from 8.70 (SD = 1.58) at baseline to 12.43 (SD = 1.83) at two weeks, and to 16.40 (SD = 2.58) at four weeks. Similarly, WBLT scores increased from 7.19 (SD = 0.76) at baseline to 10.15 (SD = 1.63) after two weeks, and 13.29 (SD = 3.16) after four weeks.

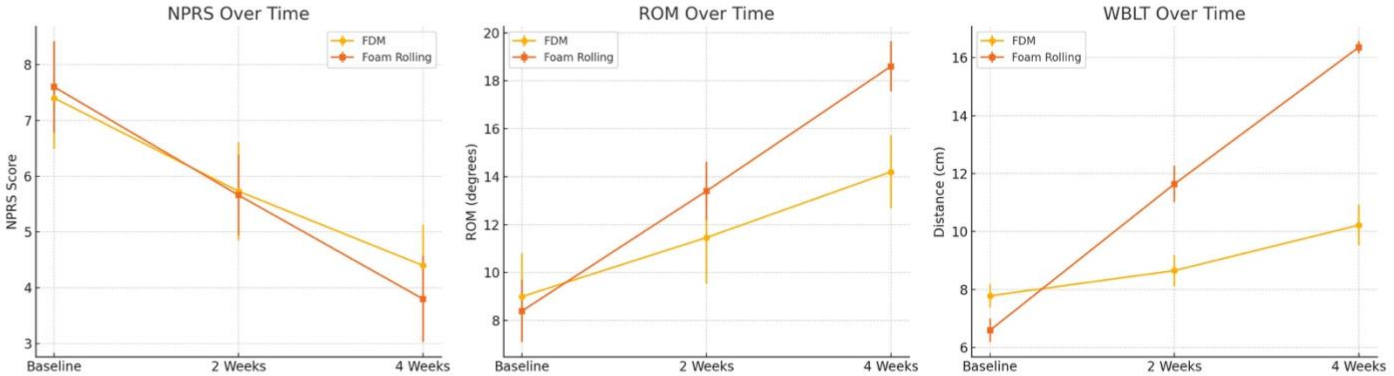

Figure 1: Line Graphs With Error Bars showing variation with time in groups

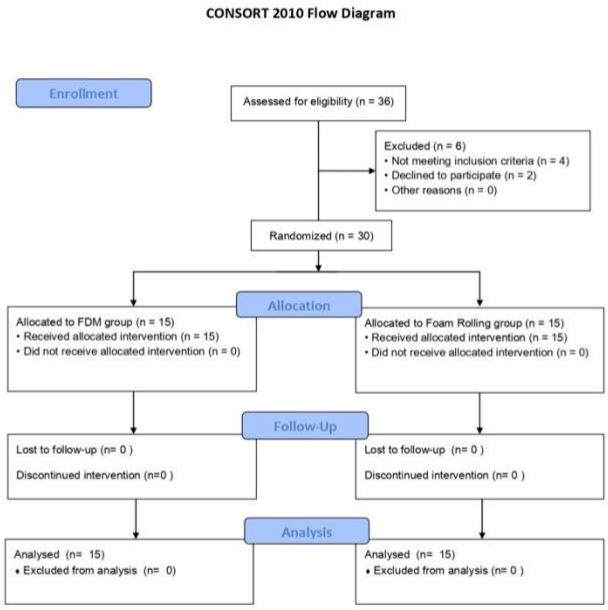

Figure 2: Consort flow diagram

Discussion

This randomized controlled trial aimed to evaluate the comparative effectiveness of the Fascial Distortion Model (FDM) and foam rolling in improving pain, calf muscle flexibility and ankle dorsiflexion range of motion (ROM) among habitual high-heel users. A total of 30 female participants were randomly allocated into two equal groups, Group A received FDM-based manual therapy, while Group B underwent a structured foam rolling intervention targeting the calf muscles.

Both intervention groups demonstrated statistically significant improvements in calf flexibility and ankle dorsiflexion. However, results from repeated measures analysis indicated that foam rolling led to significantly greater improvements than FDM in all outcome measures, including pain reduction (NPRS), ROM, and functional performance (WBLT). This suggests that foam rolling may provide more rapid and substantial benefits in altering myofascial properties and enhancing lower limb mobility in this population.

The findings align with prior research highlighting the biomechanical consequences of prolonged high-heel use. As reported by Aroob et al. (2025), extended high-heel wear induces changes such as shortening of the gastrocnemius-soleus complex, increased fascial stiffness, and decreased ankle dorsiflexion, all of which contribute to inefficient gait mechanics, higher fall risk, and long-term musculoskeletal dysfunctions. These maladaptations underscore the necessity for interventions that restore normal musculoskeletal function, both for prevention and rehabilitation (16).

Foam rolling has gained popularity due to its low cost, ease of application, and documented efficacy in modifying soft tissue characteristics. Studies by Nakamura et al. (2021) and Konrad et al. (2022) have demonstrated that foam rolling enhances ROM by disrupting myofascial adhesions, improving fascial hydration, and increasing tissue viscoelasticity (17-18). These biomechanical changes are further supported by neurophysiological mechanisms. As noted by Behm and Wilke (2022), foam rolling activates cutaneous and fascial mechanoreceptors such as Ruffini endings and Pacinian corpuscles, leading to decreased sympathetic nervous system activity and heightened stretch tolerance (19). The present study reinforces these findings, showing that foam rolling not only improves physical measures but also promotes neuromuscular relaxation and pain modulation.

Future research should therefore adopt larger and more diverse samples, incorporate extended follow-up periods, and include BMI as a covariate or stratification factor to better delineate its moderating role in treatment outcomes. In addition, investigating the combined application of foam rolling and manual therapies may provide insights into whether an integrated approach could yield additive or synergistic benefits.

Conclusion

The Both the Fascial Distortion Model (FDM) and foam rolling were found to be effective in reducing pain, improving calf muscle flexibility, and enhancing ankle dorsiflexion range of motion in individuals who regularly wear high-heeled footwear. However, foam rolling demonstrated greater and more consistent improvements across all measured outcomes when compared to FDM. This superior effect is likely due to foam rolling's comprehensive impact on fascial tissue, including its ability to modulate soft tissue mechanics, reduce neuromuscular tension, and increase stretch tolerance. Therefore, foam rolling may serve as a more practical and effective intervention in high heel footwear.

Authors' Contributions

ICMJE authorship criteria	Detailed contributions	Authors
Substantial Contributions	Conception or Design of the work	1,2,3,5
	Data acquisition	2,3,4
	Data analysis or interpretation	1,3,5
Drafting or Reviewing	Draft the work	2
	Review critically	1,2,3,4,5
Final approval	Final approval of the version to be published.	1,2,3,4,5
Accountable	Agreement to be accountable for all aspects of the work.	1,2,3,4,5

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