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Sonographic Evaluation of the Superficial Back Line Myofascial Release in Plantar Fasciitis: A Single-Blind Randomized Controlled Trial

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Abstract

Background: Myofascial tissues are interconnected, and fascia connects them to forming a web of myofascial chains. This research investigated whether incorporating myofascial release along the superficial backline offers additional benefits compared to a localized gastrocnemius release in managing clinical symptoms and plantar fascia thickness in individuals with chronic plantar fasciitis.

Methods: This was an add-on design a single-blind randomized clinical trial that was conducted with 30 chronic plantar fasciitis patients. Subjects were randomized into two groups: the Gastrocnemius Myofascial Release (G-MFR) group and the Chain Myofascial Release (C-MFR) group. Each participant underwent four MFR sessions over two weeks. Outcome measures included the Numeric Pain Rating Scale (NPRS), the Foot Function Index (FFI), and ultrasound-based evaluations of plantar fascia thickness. Due to the non-normal distribution of change scores, between-group comparisons were performed using the Mann–Whitney test with the Hodges–Lehmann estimator, and effect sizes were reported using r values.

Results: Both groups exhibited significant improvements in NPRS and FFI scores post-intervention ($P<0.001$), with the C-MFR group showing greater reductions in both measures (for NPRS: $P=0.004$, r=0.686 and for FFI: $P=0.004$, r=0.518). However, while plantar fascia thickness decreased significantly in the C-MFR group ($P=0.001$, r=0.829), no significant change was observed in the G-MFR group ($P=0.422$, r=0.206). The reduction in thickness for C-MFR compared to G-MFR was not statistically significant ($P=0.233$, r=0.222).

Conclusion: This study suggests that myofascial release in the superficial backline chain is more effective than isolated gastrocnemius release for improving NPRS and FFI scores in chronic plantar fasciitis. Future studies with longer follow-ups may clarify the long-term effects of these interventions on plantar fascia thickness.

Keywords: Plantar fasciitis, Myofascial Release Therapy, Fascia, Ultrasonography

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Introduction

Plantar fasciitis is the most common cause of heel pain, and it has a multifactorial etiology (1, 2). Some researchers suggested that limited dorsiflexion due to gastrocnemius tightness may be the most important risk factor, and releasing this muscle is a substantial part of managing plantar fasciitis patients (3-6). The hamstring - another posterior muscle of the lower limb – is also tighter in plantar fasciitis patients compared to normal people (7, 8). Restrictions within the fascial system can lead to irregular force distri-

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↑What is "already known" in this topic:
Plantar fasciitis is recognized as the leading cause of heel pain, and Myofascial release (MFR) is an effective method in plantar fasciitis. Myofascial chain is a group of several muscles that are linked together by webs of fascia. Interventions in parts of the superficial backline chain may have effects on remote areas along the chain.

→What this article adds:
Our findings indicated that myofascial release in the superficial backline chain is more effective than isolated gastrocnemius release for improving pain and function. However, there was no difference in the reduction of plantar fascia thickness between the two groups.

bution, potentially displacing bony structures from their optimal positioning, which may result in discomfort and functional impairment. Additionally, these restrictions may compress nearby nerves and blood vessels, leading to symptoms or reduced blood flow (9).

Myofascial release (MFR) is a manual therapy technique that applies gentle, sustained pressure and low-load stretching to the connective tissue to promote elongation and improve mobility in three dimensions (9, 10). Based on previous studies, MFR is an effective treatment for plantar fasciitis (11). Since the gastrocnemius muscle (like every other muscle in the body) is part of an interconnected myofascial network (12), it is thought that releasing the upper and lower segments along the chain would provide additional benefits.

Emerging research increasingly supports the concept that muscles do not function in isolation but are integrated into a complex, body-wide myofascial network, which operates like a tensegrity system. This network is interconnected by fascia, a connective tissue that adapts its tension in response to external stress. It is suggested that mechanical forces can be transmitted along designated fascial pathways, influenced by variations in muscular activity. In 1997, Thomas Meyer proposed the term myofascial chain to describe myofascial connections. He established rules based on which myofascial tissues can be divided into specific chains (13). Among the recognized fascial chains, the superficial back line (SBL) is well-established. This chain runs along the posterior aspect of the body, beginning at the soles of the feet and extending upward to the skull (14). It has been suggested that interventions in parts of the SBL may provide effects in remote areas (15). Consequently, musculoskeletal treatment strategies may benefit from targeting these fascial chains rather than focusing solely on localized structures.

Sonographic evaluations showed that increased thickness and hypoechoic fascia are the most common findings of plantar fasciitis. It could be related to an underlying reparative process of microdamage, degeneration of fibers, or fluid accumulation (16). Any factor that causes abnormal loading on the plantar fascia and accelerates the degeneration process leads to an increase in the thickness of the plantar fascia (17). Previous studies reported that along with therapeutic intervention and reduction of clinical symptoms, the thickness of plantar fascia decreases (18). Changing the thickness of the plantar fascia is a valid and reliable objective method for evaluating the impact of therapeutic interventions (19, 20).

As far as we know, no previous research has investigated the effect of MFR on the thickness of the plantar fascia. Also, even though there is evidence of the effectiveness of remote effect along the superficial backline (21-23), the comparison of myofascial chain release with isolated gastrocnemius release has not been investigated. The purpose of this add-on design clinical trial is to evaluate the additional effect of MFR in the superficial backline chain compared to MFR in the gastrocnemius muscle in patients with chronic plantar fasciitis. To achieve this, our assessments included not only pain and function subjectively but also plantar fascia thickness objectively by ultrasonography.

Methods

The present study was an add-on design single-blind randomized clinical trial (24, 25). This study was conducted between 2022 and 2023 in the physiotherapy clinic, Rehabilitation School, Iran University of Medical Sciences, Tehran, Iran. In the present investigation, informed consent was obtained from all individuals prior to participation.

Population/Patients

A pilot study was performed on 10 individuals, and then, using G-Power software and an effect size of 0.8, the sample size was calculated. A total of 35 patients with CPF were screened, and 30 patients were randomly screened. Subjects presenting with a main complaint of one-sided plantar heel pain were evaluated for eligibility. The study included both men and women aged 40 to 70 who met the following criteria: 1) gradual onset of sharp pain under the heel during weight-bearing activities after rest; 2) pain that intensifies during the first steps taken in the morning; and 3) improvement of symptoms with light physical activity such as walking. The patient history assessment included questions about pain onset, symptom duration, and any previous treatments or medications. Exclusion criteria were as follows: 1) conditions contraindicating manual therapy (e.g., malignancy, fractures, rheumatoid arthritis, osteoporosis, or severe vascular disorders); 2) pain affecting both heels; 3) history of lower limb surgery; 4) diagnosis of fibromyalgia; or 5) prior manual therapy interventions targeting the foot.

Randomization

Participants were randomly assigned to either the G-MFR or C-MFR group using blocked randomization with a block size of 4 to ensure balanced group allocation. The randomization sequence was implemented using the sealed envelope method, which was opened only after the participant had been enrolled and completed baseline assessments.

Main Outcomes

Assessments in this study included the Numeric Pain Rating Scale (NPRS), Foot Function Index (FFI), and plantar fascia thickness by ultrasound. The subjects were assessed at the baseline and 48–72 hours after intervention sessions.

Pain usually is the major complaint of patients with chronic plantar fasciitis (26). For pain measurement, the Numerical Pain Rating Scale (NPRS) was used, in which participants selected a number from 0 to 100 to represent their pain level—0 indicating "no pain" and 100 indicating "the most intense pain imaginable (27, 28)."

The functional impact was assessed using the Foot Function Index (FFI), a self-report instrument designed to evaluate foot-related pain, functional limitations, and activity restrictions. (29). The FFI consists of 23 items grouped into three subcategories. Patients rated each item on a 0 to 10 scale, where 0 indicated no pain or difficulty, and 10 represented extreme pain or dependence on assistance (29). The original FFI demonstrated high internal consistency (Cronbach's alpha = 0.96) and effectively differentiated be-

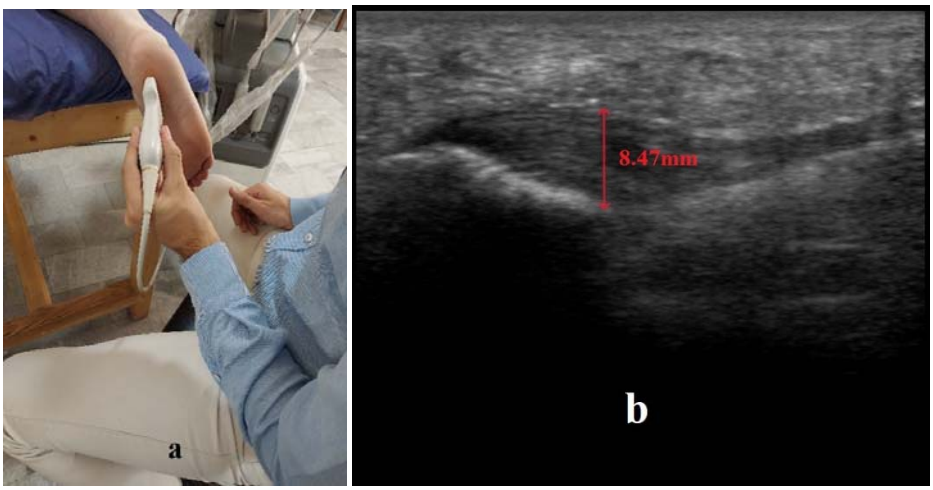

Figure 1. a. an illustration of the longitudinal ultrasound probe placement. *b.* Plantar fascia thickness measurement at the proximal insertion of the plantar fascia in a patient with plantar fasciitis.

tween individuals with and without foot pathology, indicating good construct validity (29). In this study, we utilized the Persian version of the FFI, which has shown excellent internal consistency (Cronbach's alpha = 0.95) and strong test-retest reliability (ICC ranging from 0.73 to 0.91). Construct validity was supported by significant correlations with the Manchester-Oxford Foot Questionnaire subscales (30).

All participants in the study were assessed by ultrasound imaging of the plantar fascia. Ultrasound imaging was performed using the SonoAce R7 (Samsung Medison, Seoul, South Korea), equipped with a linear-array transducer operating at 9 MHz (model L5-12/50). During the procedure, participants lay in a prone position with their feet extending beyond the end of the examination table. The examination consisted of applying ultrasonic gel to the transducer and the patient's skin. Longitudinal sonograms were obtained of the plantar aspect of the foot, and the thickness of the plantar fascia was measured at its proximal end near its insertion into the calcaneus. The thickness measurements for PF were performed three times, and their average was used for further analysis (Figure 1).

Intervention

The myofascial release techniques were performed by a physiotherapist with 10 years of manual therapy experience. Participants underwent four MFR sessions for two weeks. The therapist provided the patient with the necessary explanations regarding how to perform the intervention. The patient was told that during the intervention, he may feel stretching or mild pain, and if the pain is severe, he should inform the therapist.

Gastrocnemius - Myofascial release group: The patient lay in a prone position during the procedures with their feet over the edge of the table. The therapist fists his hand, applies pressure using body weight, and moves slowly in the distal to proximal direction. The patient slowly performs dorsiflexion and plantar flexion movements while performing the technique. The number of repetitions for each part of the gastrocnemius muscle was five times. Figure 2 (a and b) shows the gastrocnemius release techniques.

Figure 2. a. MFR of the gastrocnemius using a soft fist. *b.* MFR of the deeper layers is achieved by holding the leg in flexion to relax the gastrocnemius and using the knuckles to locate restricted areas.

Chain - Myofascial release group: The technique described in the G-MFR group was also performed in this group. In addition, plantar fascia and hamstring release techniques were also performed in this group. The patient lay in a prone position with their feet over the edge of the table. The practitioner positioned themselves at the end of the treatment table and applied pressure along the plantar fascia using the knuckles. By shifting their body weight forward, they compressed the tissue on the sole of the foot, then lifted the shoulder slightly to direct force downward through the knuckles. The practitioner repeated this motion two to three times, adjusting the angle slightly with each pass to cover different fascial lines. This movement was repeated five times. To release the lateral band of the plantar fascia, the patient lay in a side-lying position. The therapist used his knuckle between the calcaneus and the base of the fifth metatarsal to release tissue (31). Figure 3 (a and b) shows the plantar fascia release techniques.

Figure 3 (c,d,e,f,g) shows the techniques used for hamstring release. The therapist used the elbow to inhibit any excess tension in the proximal tendon of the hamstrings. Then, the client's knee was bent, and the practitioner used a fist to engage deeper tissue. The client was instructed to slowly extend the leg, returning the foot to the table surface. Another manual approach involved separating the medial and lateral hamstring muscles. The practitioner inserted pressure between these muscle groups, opening the intermuscular septum while the client gently rotated the leg inward and outward. To access the biceps femoris, the therapist used the fingers to apply pressure while the client gradually lowered the leg back to the table. The gastrocnemius tendon and popliteus are released by wrapping the therapist Chain - Myofascial release group: The technique described in the G-MFR group was also performed in this group. In addition, plantar fascia and hamstring release techniques were also performed in this group. The patient lay in a

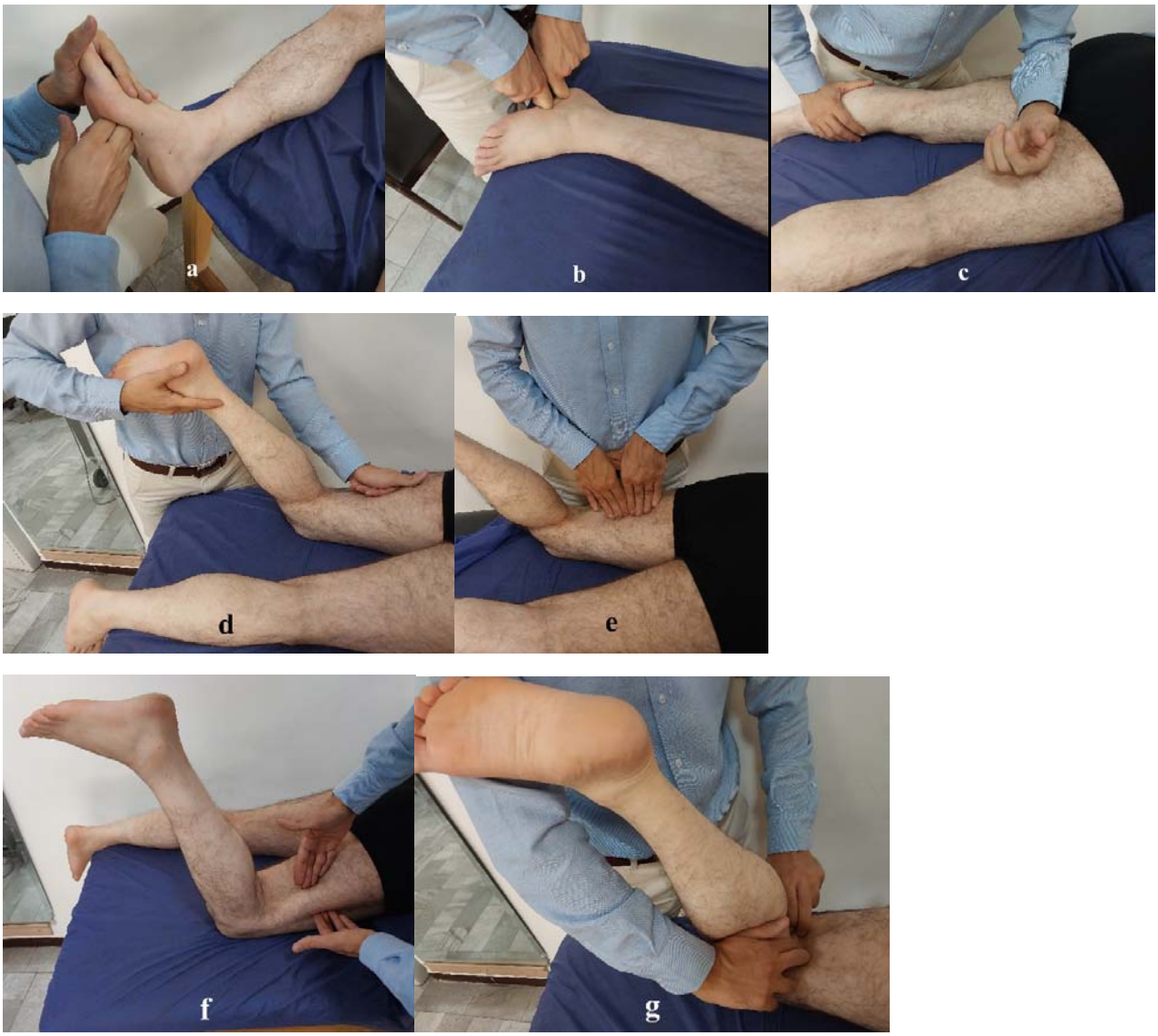

Figure 3. a. Release of the plantar fascia using knuckle. *b.* Double-handed release of the lateral band of plantar fascia. *c.* Release the hamstring tendon with the elbow. *d.* release the hamstrings by using a soft fist. *e.* release the septa between the medial and lateral hamstrings *f.* and release the lateral part of the hamstring. *g.* Releasing the gastrocnemius and popliteus.

prone position with their feet over the edge of the table. The therapist sat at the foot of the table and worked along the lines of plantar fascia with his knuckles. The therapist sank his body weight forward into the tissue on the sole of the foot and then raised his shoulder to create a downward angle on his knuckles. The therapist covers the area with two or three passes along slightly different lines. This movement was repeated five times. To release the lateral band of the plantar fascia, the patient lay in a side-lying position. The therapist used his knuckle between the calcaneus and the base of the fifth metatarsal to release tissue (30). Figure 3 (a and b) shows the plantar fascia release techniques.

Figure 3 (c,d,e,f,g) shows the techniques used for hamstring release. The therapist used the elbow to inhibit any excess tension in the proximal tendon of the hamstrings. Then he flexed the client's leg at the knee and engaged into the tissue with his fist, asking them to slowly lengthen it by returning their foot to the couch. Another technique was separating the medial and lateral hamstrings. The therapist sank into and opened the septa between the medial and lateral hamstrings while the patient turned her leg medially and laterally. The therapist used his fingers to sink to the biceps femoris while the client slowly lowered their leg toward the table. The Gastrocnemius tendon and popliteus are released by wrapping the therapist's fingers around the tendon, and the clients slowly extend their knees (30). Fingers around the tendon, and the clients slowly extend their knee (31).

Statistical Analysis

Categorical variables in this study are described using frequencies and percentages, while continuous variables are reported as means with standard deviations (SD) and medians with interquartile ranges (IQR). Since the assumptions of ANCOVA were not fully met for study outcomes, change score analysis (or gain score analysis), which is one of the alternative methods for data analysis in a pretest-posttest design, was used. The Shapiro–Wilk test was employed to examine the distribution of the changes in study outcomes. As the change scores did not follow a normal distribution, comparisons between the G-MFR and C-MFR intervention groups were conducted using the Mann–Whitney U test. The Hodges–Lehmann estimator and the related exact conditional nonparametric confidence interval (CI) were used to quantify effect sizes. The r value was used to represent effect size, where 0.1-0.3, 0.3-0.5, and >0.5 represented small, medium, and large effects, respectively. Statistical analysis was carried out using MedCalc version 19.5.3 (MedCalc Software, Ostend, Belgium), and box plots were depicted using GraphPad Prism, Version 8.0.1 (GraphPad Prism Software Inc., San Diego, CA, USA). A $P< 0.05$ was considered statistically significant.

Results

Demographic profile

A total of 30 individuals diagnosed with chronic plantar fasciitis were included in the analysis—15 participants in the G-MFR group and 15 in the C-MFR group. Baseline demographic and clinical profiles for both groups were comparable, as detailed in Table 1. Figure 4 shows the flow of participants through the trial.

Study outcomes

Numeric Pain Rating Scale (NPRS) and Foot Function Index (FFI)

To compare the scores of NPRS and FFI in patients with chronic plantar fasciitis before and after the intervention, the Wilcoxon signed-rank test was used. As can be seen in Table 2, in both groups, the median of NPRS scores decreased significantly after the intervention. Using the Hodges–Lehmann estimator, on average, the improvement (i.e., decrease) in the NPRS score in the C-MFR group was 20 (95% CI: 10 to 30) points higher than the G-MFR group (P=0.004, r=0.686); The effect size, calculated using r, was 0.686, which is considered to be large (Figure 5).

The median FFI scores decreased significantly in both groups. According to the change score analysis, the C-MFR group had a greater decrease than the G-MFR group (Mdn: -60, IQR: -70 to -40 versus Mdn: -30, IQR: -40 to -10; P<0.001). The improvement (i.e., decrease) in the FFI score in the C-MFR group was 30 (95% CI: 10 to 50) points higher than the G-MFR group (P=0.004, r=0.518); This effect size (0.518) is interpreted as large (Figure 5).

Plantar fascia thickness

To compare the values of plantar fascia thickness in patients with chronic plantar fasciitis before and after the intervention, the Wilcoxon signed-rank test was used. As shown in Table 2, in the C-MFR group, the mean values of

Table 1. Baseline characteristics of study participants

Variable	Total (n=30)	Group	
		G-MFR (n=15)	C-MFR (n=15)
Age (years), mean (SD)	52.17 (9.42)	52.67 (9.95)	51.67 (9.17)
Sex, n (%)			
Male	8 (26.7)	4 (26.7)	4 (26.7)
Female	22 (73.3)	11 (73.3)	11 (73.3)
Weight (kg), mean (SD)	79.20 (11.78)	78.07 (11.75)	80.33 (12.10)
Height (cm), mean (SD)	167.47 (9.97)	168.13 (12.76)	166.80 (6.50)
BMI (kg/m^2), mean (SD)	28.21 (3.45)	27.54 (2.29)	28.88 (4.30)
LR			
Left	14 (46.7)	7 (46.7)	7 (46.7)
Right	16 (53.3)	8 (53.3)	8 (53.3)

Abbreviations. G-MFR: Gastrocnemius Myofascial Release; C-MFR: Chain Myofascial Release; SD: Standard Deviation; BMI: Body Mass Index

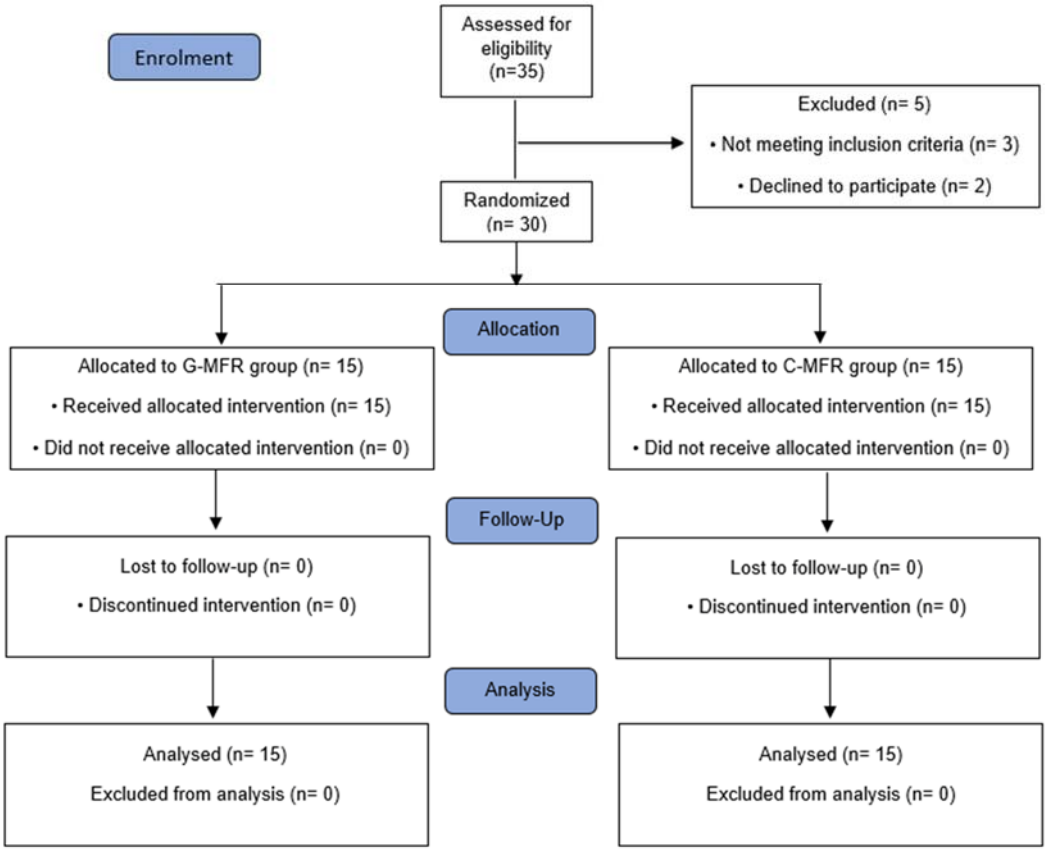

Figure 4. CONSORT flow diagram

Table 2. Comparison of NPRS, FFI, and plantar fascia thickness before and after the intervention

Variable		Pre-test	Post-test	Median difference (95% CI)	Z	P	Effect size (r)
NPRS	G-MFR	60 [30 , 80]	40 [20 , 55]	-15.0 (-22.5, -12.5)	3.32	<0.001	0.857
	C-MFR	65 [50 , 80]	25 [20 , 40]	-35.0 (-42.5 , -30.0)	3.42	<0.001	0.883
FFI	G-MFR	120 [80 , 130]	80 [60 , 100]	-30.0 (-40.0 , -15.0)	3.19	<0.001	0.823
	C-MFR	120 [90 , 160]	50 [30 , 80]	-57.5 (-70.0 , -40.0)	3.42	<0.001	0.883
Plantar fascia thickness (mm)	G-MFR	6.09 [5.19 , 6.96]	5.32 [5.05 , 7.39]	-0.14 (-0.63 , 0.29)	0.80	0.422	0.206
	C-MFR	5.65 [5.15 , 7.10]	5.13 [4.95 , 6.68]	-0.39 (-0.57 , - 0.21)	3.21	0.001	0.829

Abbreviations. CI: Confidence Interval; NPRS: Numeric Pain Rating Scale; FFI: Foot Function Index; G-MFR: Gastrocnemius Myofascial Release; C-MFR: Chain Myofascial Release
Data are shown as "Median [first quartile, third quartile]"
The P-values are based on the Wilcoxon signed-rank test
The median difference and 95% CI were calculated using the Hodges-Lehmann estimator.
Effect size (r) values of 0.1-0.3, 0.3-0.5, and >0.5 were considered as small, medium, and large effect size, respectively.

plantar fascia thickness decreased significantly after the intervention, while in the G-MFR group, there was no statistically significant difference between the values before and after the intervention.

Additionally, as depicted in Figure 6, the C-MFR group demonstrated a more pronounced median decrease in plantar fascia thickness from baseline to post-intervention compared to the G-MFR group, although this difference was not statistically significant (P=0.233, r=0.222); The effect size was 0.222, which is considered to be small (Figure 6).

Discussion

Thomas Myers introduced the concept of myofascial chains, proposing that tension in one muscular or fascial segment can influence distant regions via specific connective pathways (13, 32). Research supports the mechanical transmission of force along these chains, providing a theoretical basis for clinical application, even though empirical validation in practice remains limited. This study aimed to assess the additional benefits of myofascial release applied to the superficial backline compared to a localized gastrocnemius-focused release in individuals with chronic plantar fasciitis. Findings indicated that participants in the C-MFR group experienced greater reductions in both pain (as measured by NPRS) and functional impairment (as indicated by FFI) than those in the G-MFR group. While plantar fascia thickness significantly decreased post-intervention in the C-MFR group, the G-MFR group showed no significant change. However, no statistically significant

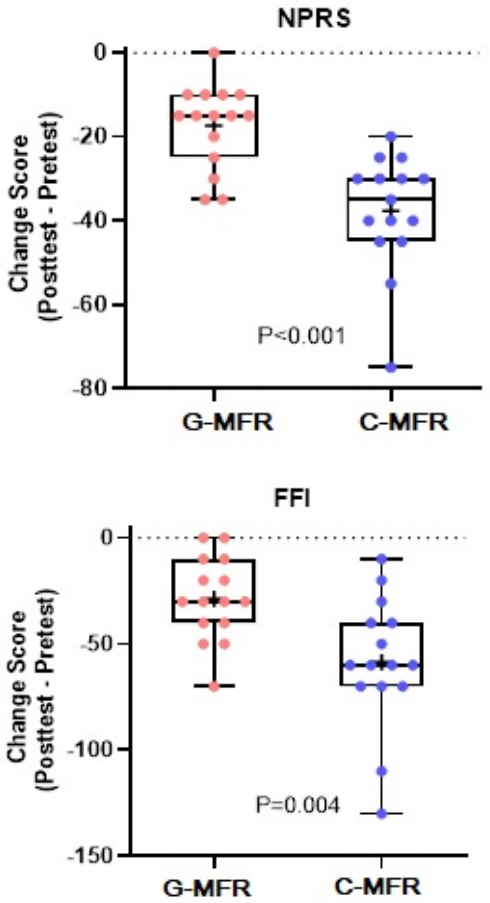

Figure 5. Results of change score analysis examining group effect on scores of the NPRS and FFI
Abbreviations. NPRS: Numeric Pain Rating Scale; FFI: Foot Function Index
Between-group differences were examined using the Mann–Whitney test.
Note. The box plot shows the minimum, first quartile (Q_1), median, third quartile (Q_3), and maximum values. The plus sign (+) represents the mean.

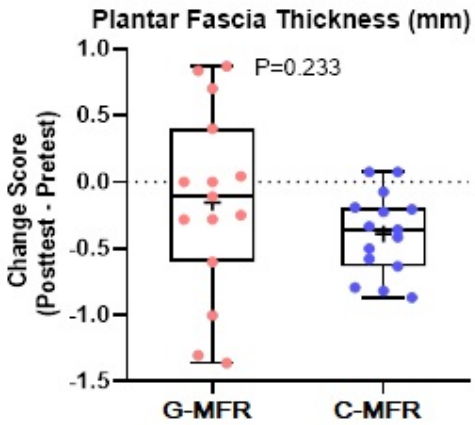

Figure 6. Results of change score analysis examining group effect on scores of the plantar fascia thickness.
Between-group differences were examined using the Mann–Whitney test.
Note. The box plot shows the minimum, first quartile (Q_1), median, third quartile (Q_3), and maximum values. The plus sign (+) represents the mean.

difference was found in the change in fascia thickness between the groups.

Previous observational studies have reported that in addition to the gastrocnemius, the hamstring muscles are also tight in patients with plantar fasciitis (7, 8). Our results show that although the tightness of the gastrocnemius muscle is known to be important in the etiology of plantar fasciitis, its release alone can not reduce the thickness of the plantar fascia. This finding can be due to the restriction in other parts of the superficial back chain (such as the hamstrings), which prevents proper biomechanical correction by creating excessive stresses and strains. Therefore, for greater effectiveness, it is necessary to consider the tightness of this muscle in the context of its myofascial chain. These results are consistent with previous literature suggesting that remote interventions can increase ROM at distant body segments (33). The biological mechanisms that explain these distant effects are still not fully understood. One theory proposes that fascia operates similarly to electrical wiring in the body, functioning as a conduit for bioelectrical communication between tissues (34). According to this view, fascia may transmit bioelectric signals generated by mechanical input, such as manual therapy, via a piezoelectric effect—whereby mechanical stress creates an electric charge in the connective tissue (35). This energy may then propagate through fascial networks across the body (36). In addition, fascia can convert mechanical force caused by the manipulation into chemical signals and transmit it through the meridians (37). However, to our knowledge, this has not been validated in vivo.

Another hypothesis suggests that mechanical manipulation alters the structural composition of fascia by reducing collagen cross-linking and promoting viscoelastic deformation. These changes may influence distant sites within the same myofascial chain through mechanical continuity (38). Based on the results of animal experiments, this effect is ascribed to myofascial connections via the perimysium shared between muscles (39). These results support James Earls' suggestion that "if a muscle seems reluctant to release or lengthen, we may achieve further release by working other muscles related to that chain (31)." another reason for this phenomenon can be related to prolonged tactile stimulation in the relevant dermatome followed by the stimulation of a greater number of skin mechanoreceptors (40, 41). Deep manual pressure, especially when slow and continuous, stimulates interstitial and ruffini mechanoreceptors, increases parasympathetic activity, and decreases overall muscle tone in the body (42). Preliminary studies have shown that interventions such as static stretching or myofascial release can acutely enhance range of motion in the contralateral limb, supporting the notion of systemic or chain-based effects (22, 43).

The degeneration process is slow and takes a long time (44). Therefore, there is still time to reverse this process after biomechanical correction. Wu et al. investigated the effect of shock wave therapy on thickness with a 12-month follow-up. They found that PF thickness decreased gradually, and at the 12-month follow-up, the decrease in thickness of the PF was significant (45). Our results showed that the thickness change of the PF has started to improve, but this improvement has not reached a significant level in the

short term. Therefore, the reason for the lack of a significant difference between the two groups in our study may be related to the short interval between treatment and assessment. It is possible that if it was followed up, the difference between the two groups would have been revealed.

Despite these findings, this study has certain limitations. First, the relatively small sample size limits the generalizability of results. The second limitation is the lack of follow-up due to time constraints. Future research is encouraged to explore the prolonged impact of myofascial release interventions. Future research should investigate the causes and mechanisms of remote effects along the SBL, not only from a biomechanical approach but also from a neurophysiological approach.

Conclusion

Myofascial release of the SBL provides greater improvement in clinical symptoms compared to local MFR on the gastrocnemius muscle. There was a greater reduction in plantar fascia thickness in the C-MFR group than in the G-MFR group, although this difference was not statistically significant.

Authors' Contributions

All authors contributed to the idea and initial design, data collection, analysis and interpretation, and manuscript writing. All authors have approved the final version of the present article and accept responsibility for the accuracy of the content.

Ethical Considerations

This study was ethically approved by the local Ethics Committee of Iran University of Medical Sciences (IR.IUMS.REC.1400.713) and was registered in the Iranian Registry of Clinical Trials (IRCT.ir); ID number: IRCT20211006052686N1.

Acknowledgment

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Conflict of Interests

The authors declare that they have no competing interests.

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