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Effectiveness of subtalar, ankle and midfoot joint mobilisation on pain, range of motion and functional activities among chronic plantar fasciitis subjects a pilot study

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Abstract
Background: Plantar fasciitis is an aseptic inflammation of the plantar fascia. It leads to pain in the foot anterior to the attachment of the plantar fascia. Each year approximately 1 million office-based physician result in a diagnosis of plantar fasciitis. The peak incidence of plantar fasciitis occurs in persons aged between 45 to 64 years and it is more common among women. In Indian population the incidence of patients with heel pain and calcaneal spur is to be 59%. The causative factors for plantar fasciitis include, overweight, walking, running or standing for long period of time, Faulty alignment of foot, old worn shoes with insufficient arch support. The patient complains of pain in the heel, which is more in morning. It gradually subsides as the patient takes a few steps. The pain increases on prolonged standing, walking etc. Tenderness can be elicited on the medial aspect of the calcaneum.
Objectives: The study's primary objective was to find out the effectiveness of subtalar, ankle, mid-foot joint mobilisation and stretching on pain, range of motion and functional activities in chronic plantar fasciitis subjects.
Subjects and Methods: The study design was a pilot study. 15 chronic plantar fasciitis subjects were selected based on selection criteria using purposive sampling method. All received joint mobilisation and stretching techniques for 3 days in a week for about 4 weeks. The total study duration was 3 months. The pre-test and post test score values of pain, range of motion and functional activities were measured by using Numerical Pain Rating scale, Goniometer and Lower Extremity Functional scale and the values were recorded for statistical analysis.
Result: The statistical analysis showed that the calculated 't' value using the paired 't' test for pain on numerical pain rating scale, range of motion of dorsiflexion, plantarflexion, inversion, eversion, subtalar inversion, subtalar eversion, midfoot supination, midfoot pronation on goniometer, functional activities on lower extremity functional scale was greater than the table value of 2.145 with $p<0.05$. Thus, the resultant of the study shows that there was significant reduction of pain, improvement of range of motion and functional activities among chronic plantar fasciitis subjects.
Conclusion: The study concluded that subtalar, ankle and midfoot joint mobilisation along with stretching was found to be effective in reducing pain, improving range of motion and functional activities among chronic plantar fasciitis subjects.
Clinical implications: The subtalar, ankle and midfoot joint mobilisation along with stretching reduces pain and improves range of motion and functional activities in chronic plantar fasciitis subjects. Increasing range of motion and functional activities controls plantar fasciitis symptoms and improves function.

Keywords: Heel pain, plantar fasciitis, Joint mobilisation, Stretching, ROM, NPRS and LEFS scale, Goniometer

1. Introduction
Plantar fasciitis is an inflammatory condition which results in pain at the inferior aspect of the heel, affecting 10-15% of the general population [1]. The patient complaints of worse pain in the morning when he attempts to take the first few steps after getting out of bed, after prolonged sitting, or when he just begins to work out [2]. Although, the majority of cases resolve within 10 months, 10% develop chronic plantar fasciitis [3]. Plantar fasciitis is the most common cause of heel pain affecting 10 -15% of the general population [1]. In Indian population the prevalence of patients with heel pain and calcaneal spur is to be 59% [4]. In United states, 10% of people may present with heel pain over the course of their lives with 83% of these patients being active working adults [5].

Up to one third of patients may present with bilateral plantar fasciitis. The peak incidence of plantar fasciitis occurs in persons aged between 45 to 64 years and it is more common among women [6]. Female subjects had a significantly increased incidence rate ratio for plantar fasciitis of 1.95 (95%) [7]. Populations at risk include persons with flat (planus) or high arched (cavus) feet, long distance runners, military personnel, person with occupation requiring prolonged standing, and persons who are obese or sedentary [6]. Plantar fasciitis is an aseptic inflammation of the plantar fascia. It causes pain in the foot anterior to the attachment of the plantar fascia [8]. It has been recognized to be associated with repeated trauma, overuse injury, improper footwear, weak intrinsic muscles Tightness and weakness in calf muscles, poor foot biomechanics and such as pes planus or pes cavus or congenital dysfunction [9]. The causative factors for plantar fasciitis include, overweight, walking, running or standing for long period of time, old worn shoes with insufficient arch support [10]. Faulty mechanics like over pronation, discrepancy in leg length, excessive tibial torsion and excessive femoral anteversion are other causative factors [11]. The plantar fascia is a broad fibrous aponeurosis that originates from the medial and anterior aspects of the calcaneus, divides into five digital slips at the metatarsophalangeal joints, and inserts distally into the periosteum at the base of the proximal phalanges [13]. The plantar facia is to maintain the longitudinal plantar arch [14]. When an individual dorsiflexes his or her toes, the plantar fascia tightens, the distance between calcaneus and metatarsals is decreased and the medial longitudinal arch is elevated. Those dynamic mechanism has been described as the windlass mechanism. This series of events is critical for maintenance of the gait cycle, where even minor arch collapse can cause great inefficiency in ambulation [15].

The plantar fascia plays a major role in this regard, primarily as a result of its anatomical position, great mechanical strength and biomechanical properties. The dynamic role of the plantar fascia, particularly its ability to assist in the propulsive phase of gait, is critical to normal foot function. The function of the plantar fascia during gait is augmented by the dynamic actions of several other extrinsic muscles of the foot. Tibialis posterior is particularly important in this regard, with the anatomic location and activity profile of the tibialis posterior muscles suggesting that it helps maintain the medial longitudinal arch during locomotion. These mechanical properties, linked with the manner of its insertion into the medial calcaneus, means the plantar fascia has a vital role in resupination of the foot during the propulsive period of the stance phase of gait [16]. The patient complains of pain in the heel, which is more in morning. It gradually subsides as the patient takes a few steps. The pain increases on prolonged standing, walking etc. Tenderness can be elicited on the medial aspect of the calcaneus [12]. Overnight, this pain recedes and the patient awakens to a stiff, painless foot until the first step out of bed. An evaluation of the ROM may demonstrate restricted dorsiflexion of the ankle, indicating a contracture of gastrocnemius fascia or Achilles tendon. A through assessment should include a complete neurovascular examination to check for paresthesias, a Tinel's and motor weakness [17]. The pathomechanics of plantar fasciitis is assumed to be due to excessive tensile loading, exacerbated by abnormal biomechanics of the legs such as pes planus, leg length discrepancy, and tightness of calf muscles [18]**.** The rehabilitation interventions aim at restoring normal muscle strength, improving muscle flexibility, and normalizing biomechanical influences by use of modalities and techniques to increase and maintain extensibility, reduce pain and maintain the foot in proper position. Manual therapy, stretching, strengthening, taping, orthosis, osteopathic manipulation, dry needling Laser, phonophoresis etc. are most commonly recommended [26].

Methodology

Study design: A pre-test, post-test pilot study design was used with interventions to assess the effectiveness of subtalar, ankle, mid-foot joint mobilisation and stretching on pain, range of motion and functional activities in chronic plantar fasciitis subjects.

Subjects: Plantar fasciitis subjects were selected using purposive sampling technique. 15 subjects with chronic plantar fasciitis was selected for this study. The study was conducted at Outpatient Department of PPG College of Physiotherapy Coimbatore. The study duration was 3 months. The treatment duration was 4 weeks. The inclusion criteria for the study includes: Age 45 to 60 years (Both male and female), Pain at the bottom of the heel, Pain in morning when taking first step, Limited ROM at ankle joint (dorsiflexion), NPRS scale score 7 to 10 (CHRONIC), Windlass test positive. The exclusion criteria's are Systemic illness, Fracture below knee, Prior foot surgery, Tarsal tunnel syndrome, Pregnancy, Heel pain (not consistent with proximal plantar fasciitis).

Methods: After getting approval, the study was conducted at outpatient department of P.P.G. College of Physiotherapy, Coimbatore. 15 Subjects with chronic plantar fasciitis was selected based on selection criteria. The aim and objectives of the study was clearly explained and the subjects were checked for general and local contraindication. All the subjects were asked to submit the written informed consent form prior to the study.

15 subjects were treated with subtalar, ankle and mid-foot joint mobilisation (Mulligan mobilisation) along with stretching. The frequency of treatment duration was three days in a week for four weeks. The pre and post test score value of pain was measured by using numerical pain rating scale, range of motion was measured by using goniometer and functional activities was measured by using lower extremity functional scale.

Description of experimental intervention

Mulligan mobilisation

The concept of Mobilizations with movement (MWM) of the extremities were first coined by Brian R. Mulligan in 2003. Mobilisation with movement (MWM) is the concurrent application of sustained accessory mobilization applied by the therapist and an active physiological movement to end-range applied by the patient. Passive end-of-range overpressure, or stretching, is then delivered without pain as a barrier. The techniques are always applied in pain free direction and are described as correcting joint tracking from a positional fault. 15 participants were randomly assigned and received mulligan mobilisation and stretching.

Mulligan mobilisation

MWM	SETS
Ankle mobilisation	
Dorsiflexion	Set 1
Plantarflexion	(10 glides)
Subtalar mobilisation	
Inversion	Set 2
Eversion	(10 glides)
Midfoot mobilisation	
Pronation	Set 3
Supination	(10 glides)

Total duration: 15 minutes

Stretching

Stretching involves application of manual or mechanical force to elongate (lengthen) structures that adaptively shortened and are hypomobile. In 1874, Dr. Andrew Taylor (US) - Osteopathic treatment utilises passive stretching of the soft tissues to restore normal structure and function.

- Improves flexibility delaying impaired mobility associated with aging
- Improves performance in physical activities as a result of improved flexibility
- Reduce the risk of injury and damage
- Improves blood circulation reducing muscle soreness and time for recovery
- Increasing the range of motion.

Stretching	Duration
Plantar fascia stretch	5 min
	6 repetitions* 1 set
	One repetition: 30 sec stretch +15 sec rest
Calf stretch	5 min
	6 repetitions* 1 set
	One repetition: 30 sec stretch +15 sec rest

Total duration: 10 minutes rest duration between each stretch: 30 seconds

Home program

Ice Massage Arch Roll

1. With involved foot resting on a frozen can or water bottle, golf ball, or tennis ball, roll the foot back and forth over the object.
2. Repeat for 3-5 minutes, 2 times per day.

Toe Curls with Towel

1. Placing a small towel on the floor, patient with his involved foot is asked to curl the towel inwards using only toes and to relax.
2. Repeat 10 times, 1-2 times per day.

Statistical analysis

The result was analysed for pre and post-test values using paired 't' test favoured for alternate hypothesis. The statistical tools used in the study are paired t-test. The paired 't' test was used for within group analysis. Pre-test and post-test values were calculated using paired 't' test at significant level of $p< 0.05$ at 14 degrees of freedom with t value of 2.262.

Results

The demographical presentation of subjects is shown in table 1. The group consists of 6 males and 9 females. The age ranges from 45-60 years. The calculated 't' value for range of motion on goniometer of dorsiflexion, plantarflexion, inversion, eversion, subtalar inversion, subtalar eversion, midfoot supination, midfoot pronation were 20.96, 16.86, 20.15, 14.65, 15.09, 15.17, 14.41, 8.60 respectively which was greater than the table value of 2.145 with $p<0.05$. And the calculated 't' value for functional activities on lower extremity functional scale was 12.23 which was greater than the table value of 2.145 with $p<0.05$. Thus, the resultant of the study shows that there was significant improvement and difference between pre-test and post-test values.

Table 1: Demographic characteristics of subjects

Age	45- 60 Years 45-48 = 4 members 2 males, 2 females 49-53 = 6 members 2 males, 4 females 54-57 = 3 members 1 male, 2 females 58-60 = 2 members 1 male, 1 female
Gender	Females 9 Males 6
NPRS	7 – 10
LEFS	40 – 50

Table 2: within group analysis of pain using NPRS among subjects with chronic plantar fasciitis during preintervention and post-intervention phase.

Outcome parameter	Group	Mean	SD value	T-value
NPRS	Pre-test	8.3	0.5	11.81
	Post-test	4.6	0.3	

The table 2 analysis showed that the calculated 't' value using the paired 't' test for pain on NPRS was 11.81 which was greater than the table value of 2.145. Hence the statistical report states that there was statistically significant in reduction of pain after the application of intervention.

Table 3: within group analysis of functional activities using LEFS among subjects with chronic plantar fasciitis during preintervention and post-intervention phase.

Outcome parameter	Group	Mean	SD value	T-value
LEFS	Pre-test	47.12	4.38	12.23
	Post-test	53.8	3.93	

The table 3 analysis showed that the calculated 't' value using the paired 't' test for functional activities on LEFS was 12.23 which was greater than the table value of 2.145. Hence the statistical report states that there was statistically significant in reduction of pain after the application of intervention.

Table 4: within group analysis of range of motion for ankle, subtalar and midfoot joint using goniometer among subjects with chronic plantar fasciitis during preintervention and post-intervention phase.

Joint	Motion	Group	Mean	SD value	T-value
Ankle joint	Dorsiflexion	Pre-test	12	0.9	20.96
		Post test	18.5	0.6	
	Plantarflexion	Pre-test	39.6	1.88	16.86
		Post test	49.8	0.98	
	Inversion	Pre-test	27.2	1.19	20.15
		Post test	35.4	0.73	
	Eversion	Pre-test	9	0.74	14.65
		Post test	15.6	0.78	
Subtalar joint	Inversion	Pre-test	2.8	0.5	15.09
		Post test	5.4	0.1	
	Eversion	Pre-test	2.4	0.1	15.17
		Post test	5.6	0.1	
Midfoot joint	Supination	Pre-test	12.8	0.7	14.41
		Post test	18.2	0.5	
	Pronation	Pre-test	1.9	0.3	8.60
		Post test	4.4	0.1	

The table 4 analysis showed that the calculated 't' value using the paired 't' test of range of motion for ankle dorsiflexion, plantarflexion, inversion, eversion was 20.96,16.86,20.15and 14.65 respectively. For subtalar inversion and eversion was 15.09 and 15.17 respectively and for midfoot supination and pronation was 14.41 and 8.60 using goniometer which was greater than the table value of 2.145. Hence the statistical report states that there was statistically significant in reduction of pain after the application of intervention.

Discussion

Plantar fasciitis is an inflammatory condition which results in pain at the inferior aspect of the heel, affecting 10-15% of the general population. It is the most common cause of heel pain in the population aged above 40 years. It is characterized by heel bone tenderness and functional restriction that affects 10% of general population.

In 2022 Subasi *et al*., conducted a study to evaluate mulligan concept treatment for chronic plantar fasciitis. A total of 25 patients with chronic PF were included in the study. The patients were randomly divided into Mulligan concept rehabilitation group and Home Rehabilitation group. They concluded that both Mulligan mobilization with movement (MMWM) and exercise protocols are effective for chronic PF.

In 2021 Muhammad Kashif *et al*, conducted a study to evaluate effectiveness of subtalar mobilisation technique on pain and functional disability compared with conventional physiotherapy in PF subjects. The participants were randomly assigned to intervention group A, that received subtalar mobilisation, and control group B treated with therapeutic ultrasound. Of the 60 patients enrolled, 8(13.3%) were lost to follow-up, while 52(86.6%) completed the study. Of the 52 subjects, there were 25(48%) in group A with a mean age of 32.40±8.02 years, while in group B there were 27(52%) subjects with a mean age of 32.59±7.00 years. Mean body mass index for group A was 25.35±3.8 compared to 25.67±3.25 for group B. There were significant differences in terms of pain between the two groups. They concluded that subtalar mobilisation with movement was found to be effective than conventional treatment.

In 2015, Anat Shashua *et al*., conducted a study to "evaluate the efficacy of ankle and mid-foot mobilisation on pain and function with PF subjects". Fifty patients with PF, aged 23 to 73 years, were randomly assigned to either the intervention or control group. Both groups received 8 treatments, twice a week, consisting of stretching exercises and ultrasound.

In addition, the intervention group received mobilization of the ankle and midfoot joints. Dorsiflexion range of motion was measured at the beginning and at the end of treatment. The results were evaluated by 3 outcomes: the numeric pain-rating scale, Lower Extremity Functional Scale, and algometry. Both groups showed a significant difference in the numeric pain-rating scale and Lower Extremity Functional Scale. Both groups significantly improved in dorsiflexion range of motion, with no difference between groups.

In 2020 H Boochum *et al*., conduct the study to evaluate the effect of a home-based stretching exercise on multi-segmental foot motion and clinical outcomes in patients with plantar fasciitis. A single group pre- and post-test design was conducted for this study in 20 patients with PF. They concluded that home-based stretching exercise was an effective program for reducing pain, enhancing muscle strength for both extrinsic and intrinsic foot muscles in patients with Plantar Fasciitis.

The previous studies demonstrated the effectiveness of Movement with Mobilisation (MWM) and Stretching for Chronic Plantar Fasciitis.

The present study demonstrates the effectiveness of Ankle, Subtalar and Midfoot mobilisation along with stretching on pain, range of motion and functional activities among chronic Plantar Fasciitis subjects. The study concluded that the subtalar, ankle and midfoot mobilisation with movement along with stretching was found to be effective in reducing pain, improving range of motion and functional activities among chronic plantar fasciitis subjects. The data analysis showed that obtained results was greater than the observed values. Statistical analysis is also evidence for significant reduction and improvement. Eventually, alternative hypothesis is accepted. The mechanism for this significant improvement could be of the following reasons: MWM which is a combination of an active movement with simultaneous passive accessory mobilization which helps in restoration of movement. MWM is effective by neurophysiological mechanism of production of initial hypoalgesia based on stimulation of peripheral

mechanoreceptors and inhibition of nociceptors and altering sympathetic nervous system and biomechanical concept of positional fault correction. The active movement stimulates the proprioceptive tissues, such as Golgi tendon organ by stretch. MWM repositions the joint, causing it to track normally.

Stretching helps to prevent contractures, is one of the reasons for the improvement in gross motor functions. During passive stretch, both the longitudinal and lateral force transduction occurs in the connective tissue, and tension rises sharply. After a particular point, there is a mechanical disruption of cross bridges as the filaments slides apart, leading to abrupt lengthening of sarcomeres. When the stretch force is released, the individual sarcomeres return to their resting length. If more permanent length increases are to occur, the stretch force must be maintained over an extended period of time.

Neurophysiologically, when a muscle is stretched, the primary afferent fibres stimulate the alpha motor neurons in the spinal cord and facilitate contraction of the extramural fibres, increasing tension in a muscle. If a slow stretch force is applied to the muscle, the Golgi tendon organ fires and inhibits the tension in the muscle, allowing parallel elastic component of the muscle to remain relaxed and lengthen.

Limitations

1. This study was a short-term study.
2. This study did not include a control group.
3. The study was done using a small sample size.

Further direction of the study

1. A similar study may be extended with large sample size.
2. A similar study with longer duration can be performed for more effectiveness.
3. Future study can be compared with various techniques.
4. Having a control group is desirable.

Conclusion

The study concluded that there is a significant improvement in reduction of pain, improving range of motion and functional activities following the application of 4 weeks of subtalar, ankle and midfoot joint mobilisation along with stretching in chronic plantar fasciitis subjects.

The present study adds value to the literature that applying the subtalar, ankle and midfoot joint mobilisation along with stretching was found to be effective in reducing pain, improving range of motion and functional activities among chronic plantar fasciitis subjects.

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Authors contribution

I understand my agreement to participation in this study and I am not waiving any of my legal rights. I confirm that Mr. Pranesh Sam.G / Dr. C. Sivakumar MPT (ORTHO)., PhD have explained me the purpose of study, the study procedure and possible risk that I may experience. I have read and I have understood this concern to participate as a subject in this study.

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