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A study to compare the effect of ultrasound and foam roller exercise, with ankle foot exercises, on pain and foot function, in patients with plantar fasciitis.

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Background:- Plantar fasciitis, a common cause of heel discomfort, affects individuals aged 25 to 65 and is frequently aggravated by biomechanical defects, extended standing, and overuse. Effective conservative therapies are critical to functional improvement and pain alleviation.

Objective: - The purpose of this study was to compare the effect of ultrasound and foam roller exercises, with exercises for ankle and intrinsic foot muscles, on pain and foot function, in patients with plantar fasciitis.

Methodology:-A Quasi-experimental comparison investigation was done on 20 people (aged 18-60), who were allocated evenly into two groups. Group A had Ultrasound therapy, stretching with foam roller. In Group B no modalities were used and only ankle and intrinsic foot muscle exercises were taught. Pain and functional status were measured using the Visual Analog Scale (VAS) and Foot Function Index (FFI), respectively.

Result:-.The results of the study showed that there was significant difference within the groups in pre-test and post-test measures ($p<0.05$) suggesting that both treatments were effective in reducing pain and improving foot function. As there was no significant difference in analysis of post test scores between the groups ($p>0.05$), it can be concluded that both treatments had similar effects only.

Conclusion:-The study shows that there was no significant difference between the two groups and that both treatments(Group A-Ultrasound and foam roller versus Group B-Ankle and foot muscle exercises) were effective in reducing pain and improving foot function in patients with plantar fasciitis.

Keywords: Plantar fasciitis, Ultrasound, Ankle & Foot ExerciseINTRODUCTION

An inflammation of the plantar fascia's origin and surrounding perifascial structure is known as plantar fasciitis.[1,2] Plantar fasciitis is also referred to as heel pain, plantar fasciopathy, jogger's heel, painful heel syndrome, heel spur syndrome, runner's heel, subcalcaneal pain, calcaneodynia, and calcaneal periostitis.[3,4,5,2]

Although the precise prevalence and incidence of plantar fasciitis (PF) by age are unknown, estimations indicate that the condition accounts for about 1 million medical visits per year. Approximately 10% of the general

population suffers from plantar fasciitis, and 83% of those affected are active, working people between the ages of 25 and 65. The general population between the ages of 40 and 60 has the highest incidence.[6,7] In a third of instances, plantar fasciitis may manifest bilaterally. Furthermore, PF was more common in women than males, in those aged 45 to 64 vs those aged 18 to 44, and in those with a body mass index of more than 25 kg/m2.[8,9]

The plantar fascia starts from the medial calcaneal tuberosity and is divided into into three bands: medial, central, and lateral. These bands link to the superior surface of the abductor hallucis (AbH), flexor digitorum brevis(FDB), and abductor digiti minimi (AbDM) muscles, respectively.[6,10,11] The core part is thick, with thinner medial and lateral bands that support the longitudinal arch. The triangular structure is separated into five bands at the mid metatarsal level, each with a deep and superficial tract.[6,12] The plantar fascia connects these rods at their base.

The arch depresses, the two rods split apart, and tension is dispersed throughout the plantar fascia when force is applied to the medial longitudinal arch's (MLA's) apex. The calcaneo navicular ligament (spring ligament) and the long and short plantar ligaments are the primary ligaments that support MLA.[6,11] Between the flexor digitorum longus (FDL) and the flexor hallucis longus (FHL), in the posterior compartment of the lower leg, is the tibialis posterior. It is a key muscle that support The foot's medial arch. Adults with tibialis posterior dysfunction may have flat feet and poor arch control. Abductor hallucis, flexor digitorum brevis, and flexor hallucis longus help support and resupinate the foot.[11,13]

It has been described that the plantar fascia has special anatomical characteristics that enable it to connect the primary tarsal bones with the fore foot ligaments. In this sense, the plantar fascia preserves the integrity of the medial longitudinal arch by passively stabilizing the foot [14] or functioning as a mechanical truss [15,16]made the intriguing discovery that, while having an

archiform appearance, the foot is not structurally a genuine arch; that is, its arched shape cannot be maintained only by its own geometry. Instead, the arch of the foot depends mostly on nearby soft tissues to stay in that posture. Because of its anatomical location, high mechanical strength, and

biomechanical characteristics, the plantar fascia is important in this respect. Progressive pes planus and related problems can result from plantar fascia rupture and partial or whole surgical sectioning.[17] However, this depends on the surgical release or rupture site. Although there may be very slight changes in arch confirmation following partial sectioning,[18] note that any deviation from the norm could set off a series of events that ultimately result in symptomatic pes planus.

Plantar fasciitis is typically caused by overuse, resulting in micro-tears in the plantar fascia. However, this syndrome might be caused by trauma or a variety of other factors. Some susceptible characteristics include pes planus, pes cavus, limited ankle dorsiflexion, prolonged standing or jumping, and severe pronation /supination.[15,19] Pes planus can increase strain on the plantar fascia. Pes cavus can put a lot of strain on the heel due to poor shock absorption. Patients with this illness often experience tightness in their posterior leg muscles, including the gastrocnemius and soleus. Tight muscles can disrupt the normal biomechanics of walking. When taking their initial few steps in the morning, patients typically report heel pain, which becomes better as they walk. They usually report that the examiner determined that the medial calcaneal tubercle is the location of the

pain. There is typically no history of a cut or trauma and the pain is subtle. A lot of patient says they think the disease is caused by a stone bruise or a recent increase in their everyday activities. It is common for patients to experience symptoms for years and attempt to manage the mat home before seeking medical attention.[20]

Patients with chronic symptoms would need a more rigorous rehabilitation program, while early or "reactive" plantar fasciitis may resolve with modest therapies and relative rest. Plantar fascia stretching and strengthening are part of management, along with efforts to lessen or address any contributing factors, such as excessive heel impact and inadequately supportive footwear. By gently stretching the plantar fascia while maintaining the foot in dorsiflexion, night splints or "Strasbourg socks" may offer some relief.[21]

Corticosteroid injections in to the proximal plantar fascia frequently provide temporary pain relief, but they also raise the possibility of rupture and can cause the heel fat pad to atrophy, which can result in chronic pain. Musculoskeletal experts have recently come to favor localized

injection of autologous blood or platelet-rich plasma as a viable treatment for plantar fasciitis with encouraging early results.[22,23]

In patients with plantar fasciitis, several studies have shown the advantages of ultrasound and foam roller exercise. However, limited studies compared the effects of exercises alone with modality treatments such as ultrasound, as pain prevents patients from performing exercises. In this study patients were encouraged to reduce pain with hot water fermentation, when required, and encouraged to begin exercises from the beginning of treatment session thus educating them to overcome pain with activity and exercise.

METHODOLOGY

STUDY DESIGN: Quasi experimental study

STUDY TYPE: Comparative study

STUDY POPULATION: 18-60years (both male and female)

STUDY SAMPLE: 20

STUDY DURATION: 6weeks

STUDY SET UP: Physiotherapy division, NIEPMD (Divyangjan)

SELECTION CRITERIA:

Inclusion Criteria:

- Age>18 years
- Pain while taking few steps in early morning
- Pain score>5
- Pain on palpation along the proximal plantar fascia
- Positive Windlass test

Exclusion Criteria:

- Traumatic injuries

- Patient under analgesics
- Peripheral vascular diseases
- Calcaneal stress fractures
- Underwent any foot or heel surgeries

Variables:

A) Dependent variable:

- Pain
- Disability
- Activity limitation

B) Independent variable:

- Gender
- Ultrasound
- Foam roller exercise
- Ankle foot exercise

OUTCOME MEASURES AND TOOLS:

The main outcome measures include:

- To measure pain by using Visual Analog Scale(VAS)
- To measure functional status of foot using Foot Function Index(FFI)

VISUAL ANALOG SCALE (VAS):

A Visual Analog Scale (VAS) is a useful tool for measuring characteristics or attitudes that are difficult to directly measure due to their broad range of values. The symptom severity scale ranges from0 (no symptoms) to 10 (extremely severe symptoms) and is often represented by a horizontal line of 100mm length with word descriptors at each end. The patient marks the point that they believe symbolizes their

current state. To establish the VAS score, measure in millimeters from the left end of the line to the point marked by the patient. These scales are most effective for analyzing individual changes rather than comparing groups of people at a single point in time.

These scales are most useful when examining change within people and are less useful when comparing a group of persons at a single moment in time because such an assessment is obviously very subjective. One could argue that a VAS attempts to generate interval/ratio data from subjective values that are ordinal at best. As a result, care must be used when working with such data. To avoid reading too much into the particular VAS score, many researchers choose to employ an analysis approach based on the rank ordering of scores rather than their exact values.

FOOT FUNCTION INDEX (FFI)

A Foot Function Index (FFI) was created to asses show foot pathology affects function in terms of pain, disability, and activity restriction. The foot function index (FFI) assesses a patient's foot pain and difficulty with

foot-related activities over the past week. The FFI is a self-administered index made up of 23 items organized into three sub-scales. Both total and sub-scale scores are generated.

The FFI is a self-administered questionnaire with three sub scales :-

- Foot Pain sub-scale(9 items)
- Disability sub-scale(9items)
- Activity Limitation sub-scale(5 items)

Totaling 23 items for evaluating patients with foot illnesses.

The FFI was assessed for test-retest reliability, internal consistency, construct and criterion validity. The test-retest reliability of the FFI total and sub scale scores ranged from 0.87 to 0.69. Internal consistency ranged between 0.96 and 0.73.The FFI index was found to have a strong connection with clinical markers of foot disease, supporting its criterion validity.

PROCEDURE:

This study is a quasi-comparative study. Patient received therapy in a National Institute for Empowerment of Person with Multiple Disabilities (Divyangjan), Physiotherapy division and consent was taken from the patient. Patient was checked for the inclusion criteria, exclusion criteria and was assessed completely. Patient history and demographic data was collected and normal orthopedic assessment was taken in physiotherapy unit.

All of the participants, both male and female, met the predetermined inclusion requirements. At the second sampling stage, 20 subjects were conveniently assigned to groups A and B respectively, and was given a particular physiotherapy treatment. Patients were taught and explained about the methods of intervention. All subjects had undergone two measurements, one on entry to the study (pre-test) and one after the 6 weeks of intervention period (post-test).

GROUP A

- Ultrasound for1 week for 10 minutes.

→Frequency :-1 MHz

→ Mode :-continuous

→ Intensity:- 1-1.5W/cm^2

→ Duration :- 10minutes

- Foam roller exercise for6 weeks for 10 minutes.

→ for calf muscles in long sitting position.

→ For plantar fascia in standing position.

→Ankle and foot Range of Motion exercises

GROUP B

- Warm up exercise including:

→Calf muscles stretching in standing position

→Plantar fascia stretching in sitting position on chair

(Intensity: - 3 sets each of 30 sec hold for 1 time a day for 6weeks)

- Ankle range of motion exercises including:

→ Plantar flexion

→ Dorsi flexion

→ Inversion

→ Eversion

- Intrinsic foot muscle exercises

✓ Short foot exercises
✓ Toe spreads
✓ Toe extensions
✓ Towel curls
✓ Marble pick ups
✓ Barefoot walking

(Intensity: - 2 sets each of 4 sec hold for 10 repetition a day for 2 weeks, slowly progressing to 20 repetitions in week 4 and 30 repetitions in week 6)

DATA ANALYSIS AND INTERPRETATION

All the data analyses in the present study were performed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM, Chicago, IL, USA). A Sample of paired t test was performed to determine the mean of the VAS and FFI. Paired sample t test was used to examine the changes in outcome variables prior to and after the intervention in each group. The level of significance was fixed at $p < 0.05$

TABLE : THE DESCRIPTION OF THE 'P'VALUE ABOUT THE SIGNIFICANCE LEVEL

'P'VALUE	DESCRIPTION
<0.0001	ExtremelySignificant
0.0001-0.001	ExtremelySignificant
0.001-0.01	VerySignificant
0.01-0.05	Significant
>0.05	Not Significant

TABLE: CHARACTERISTICS OF THE PARTICIPANTS OF GROUP A AND GROUP B

Characteristics	Group A	Group B
Number of participants	10	10
Sex	Male=3, Female=7	Male=1, Female=9
Age in years(mean)	31.7	25.6

The mean age for the Group A was 31.7 and mean age for the Group B was 25.6

TABLE : SHOWS DIFFERENCE IN VAS AND FFI VALUES IN GROUPA

Scale	Pre mean± SD	Post mean±SD	t- value	p- value
VAS	**7.40±.699**	**4.50±.972**	**10.474**	**<.000**
FFI	**35.50±3.979**	**22.80±4.566**	**6.196**	**<.000**

This table shows the significant difference between pre and post test measures in Group A ($p<0.05$)

TABLE : SHOWS DIFFERENCE IN VAS AND FFI VALUES IN GROUP B

Scale	Pre mean± SD	Post mean± SD	t- value	p- value
VAS	**7.20±.789**	**3.60±.966**	**9.000**	**<.000**
FFI	**35.90±5.065**	**20.20±5.116**	**10.582**	**<.000**

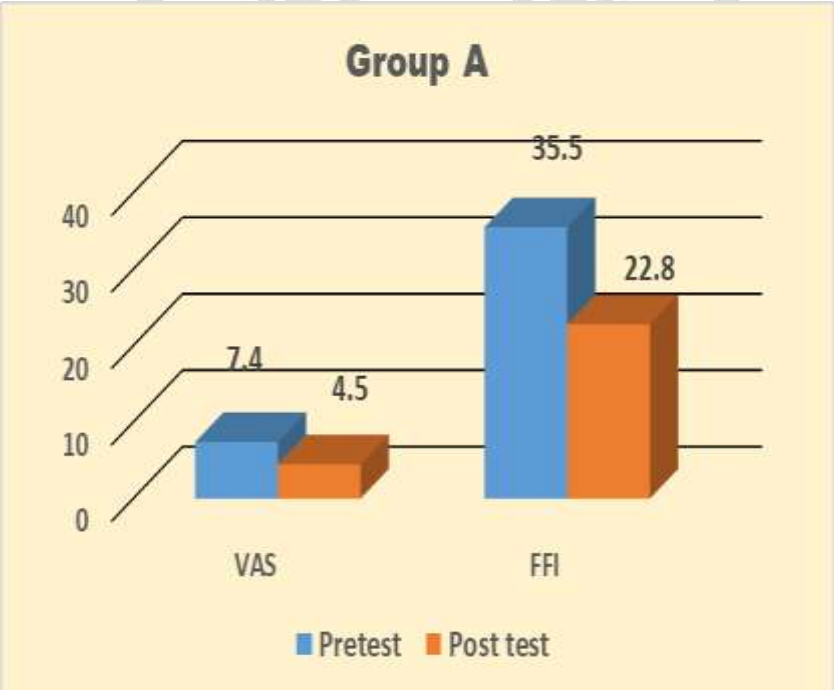
This table shows the significant difference between pre and post test measures in Group B ($p<0.05$)

TABLE : COMPARISON OF THE PRE AND POST VALUES OF VAS AND FFI IN THE GROUP A AND GROUP B

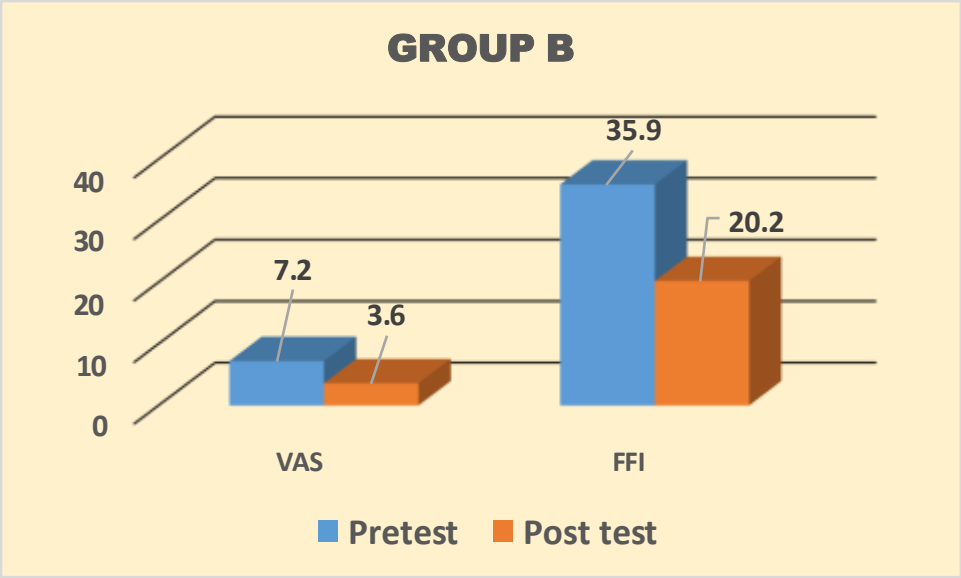
Scale	Mean difference ±SD	t - values	p - value
VAS	**-.700± .486**	**-1.439**	**.297**
FFI	**2.530± -8.316**	**-1.186**	**.251**

This table compares data of Group A and B and shows that there is no significant difference in effect between the groups. ($p>0.05$)

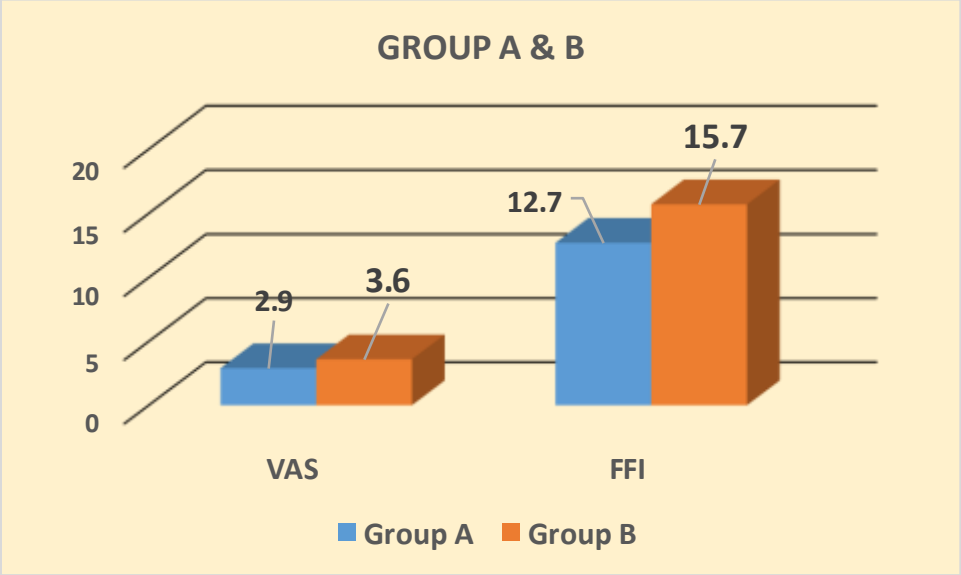
Within group analysis in Group A



Within group analysis in Group B



Between groups analysis shows insignificance in improvement of outcomes:



RESULTS

The result of "Group A" for Pain intensity score as measured by (VAS), using paired 't' test showed that the pre-test mean was found to be 7.40, with standard deviation 0.699 and the post-test mean was found to be4.50, with standard deviation 0.972 revealing 't' value of 10.47 with p value <0.000 indicating extremely significant difference between the pre-test and post-test scores. And for Functional status of foot asmeasured by (FFI), using paired 't' test showed that the pre-test mean was found to be 35.5, with standard deviation of 3.97 and the post-test mean was found to be 22.8 , with standard deviation 4.56 revealing 't' value of 6.19 with p value <0.000 indicating extremely significant difference between the pre-test and post-test scores.

In contrast, the result of "Group B" for Pain intensity Score as measured by (VAS), using paired 't' test showed that the pre-test mean was found to be 7.20, with standard deviation .789 and the post-test mean was found to be

3.60 with standard deviation .966 revealing 't' value of 9.000 with p value <0.000 indicating extremely significant difference between the pre-test and post-test scores. And for Functional status of foot as measured by (FFI), using paired 't' test showed that the pre-test mean was found to be35.90, with standard deviation of 5.065 and the post-test mean was found to be 20.20, with standard deviation 5.116 revealing 't' value of 10.582 with p value <0.000 indicating extremely significant difference between the pre-test and post-test scores.

The results of " between group analysis" for Pain intensity Score as measured by (VAS), using independent 't' test showed that F value was 1.15 with mean difference of -.700 revealing 't' value of -1.439 with p value .297 indicating the difference in the VAS scores between two groups is statistically insignificant. And for Functional status of foot as measured by (FFI), using independent 't' test showed that F value was1.407 with mean difference of -3.00 revealing 't' value of -1.186 with p value
.251 indicating the difference in the FFI scores between two groups is statistically insignificant.**SCUSSION**

This study aimed to compare the effectiveness of Ultrasound therapy and Foam roller exercises, with exercises for the ankle and intrinsic foot muscles, in managing Plantar Fasciitis. The minimum age of the participant in this study was 21 and the maximum age was 46 years. Female participants were more than the male participants in this study. In some studies gender to play a role in the development of Plantar Fasciitis and women are considered to be the most often affected with Plantar Fasciitis.[53]

The findings indicate that Group A that got Ultrasound therapy along with stretching exercises with a foam roller and Group B that got only ankle and foot exercises is equally effective in reducing pain and improving functional status, as demonstrated by significant improvements in VAS and FFI scores within each group. However, the inter-group comparison showed no statistically significant differences, suggesting that both treatments provide comparable benefits.

For Pain reduction both interventions were effective in reducing pain, as reflected in the significant reductions in VAS scores. These reductions highlight the effectiveness of both methods in alleviating the hallmark symptom of plantar fasciitis pain. For Functional improvement significant improvements in functionality, as measured by the FFI, were observed in both groups. These findings indicate that both interventions contributed to restoring foot function and improving mobility.

The mechanism of the therapeutic ultrasound is believed to be the reason behind its positive effect on pain, as it can increase the temperature and metabolism of tissues in addition to the increase of blood flow. It also helps to improve tissues flexibility and mobility by softening them. Moreover, it increases the chemical activity and the cell membrane's permeability (Baker, Robertson & Duck, 2001). Additionally, it has been suggested that ultrasonic energy influences the chemical activity of tissues by making cell membranes more permeable, controlling the formation of molecules and proteins, and possibly promoting tissue recovery and speeding up the healing process (Al-Siyabi et al., 2022) due to the deep heating effects of ultrasound, which enhances local blood circulation, reduces inflammation, and promotes tissue healing.

Ultrasound therapy can provide internal tissue massage action for plantar fascia that is produced by longitudinal waves, causing mechanical vibration bundles to vibrate, causing changes in intracellular pressure (Krukowska et

al., 2016). These mechanical vibration bundles cause a range of regulatory phenomena that significantly reduce pain

and swelling, speed up the healing process, and standardize immune responses. These phenomena result from enhanced tissue perfusion and oxygenation, quicker prosthetic group enzyme activity, the release of mediators, and enhanced cell and intercellular membrane penetrability (Krukowska et al., 2016).

In contrast, foam rolling with self-stretching had a significant effect in the reduction of the pain. The increased blood flow to the muscles results in removal of the waste products which are responsible for pain reduction. It also activates the cutaneous receptors which are responsible for blocking of nociceptive stimulus. Foam rolling also causes a noticeable reduction in the tissue adhesions and stiffness which causes increase in muscle tendon compliance. Due to this there is a decrease in the cortisol level and increase in the dopamine and serotonin levels, which are responsible for pain reduction. [54,55]

It is also found that foam rolling with self-stretching improved ROM. This is possibly because of the change in fascia properties. The frictional movement between the foam roller and fascia tissues causes a warming effect on the fascia, resulting in breakage of adhesions due to which extensibility and flexibility of fascia is restored. [56] The foam roller causes back and forth motion of soft tissues and causes pressure on it which causes overloading of the cutaneous receptors. The end result of the friction created between foam roller, fascia and muscle is a stretch which may decrease the sensationsof stretch end points. [57,58] These findings are in line with study which stated that foam rolling was effective in increasing ROM. [59]

Similarly ankle and foot muscle exercises were initially begun few repetitions and progressively the repetitions were gradually increased. If pain persisted patients were encouraged to use hot water fermentation as a home remedy when required. Predominantly they were managed with active exercises only. This helped them to manage their pain perception as well as overcome fear of pain as seen by improvements in FFI score. This shared component of the interventions might explain the lack of significant differences between the groups.

The similarity in outcomes may be attributed to the shared emphasis on addressing key factors in plantar fasciitis management, such as pain modulation, tissue flexibility, and biomechanical correction. Both modalities appear to achieve these goals through different yet equally effective mechanisms.

CONCLUSION

From this study we conclude that both ultrasound therapy and foam roller exercises, and only ankle and intrinsic foot muscle exercises without use of modalities were, equally effective in managing plantar fasciitis. Both interventions result in significant pain reduction and functional improvements, offering clinician's flexibility in designing patient-specific treatment plans.

LIMITATIONS

This study has several limitations. The small sample size (n=10 per group) reduces the statistical power and limits the generalizability of the findings. Additionally, the short follow-up period precludes an assessment of long-term outcomes, such as the sustainability of pain relief and functional improvements. Differences in demographic characteristics, such as age and sex distribution, may also have influenced the results.

RECOMMENDATION

Future studies should include larger and more diverse samples to validate these findings and assess their applicability to broader populations. Long-term follow-up studies are necessary to determine the durability of treatment effects and evaluate recurrence rates.

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