International Journal of Physical Education, Sports and Health 2022; 9(5): 215-221

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2022; 9(5): 215-221

www.kheljournal.com
Received: 09-08-2022
Accepted: 13-09-2022

Chaitra G
Lecturer, Kempegowda Institue of Physiotherapy, Bangalore, Karnataka, India

Maheswari P
Associate Professor, Padmashree Institute of Physiotherapy, Karnataka, India

Corresponding Author:
Chaitra G
Lecturer, Kempegowda Institue of Physiotherapy, Bangalore, Karnataka, India

A comparative study-effect of phonophoresis versus myofascial release as treatment on plantar fasciitis

Chaitra G and Maheswari P

Abstract
Background and Objective: Plantar fasciitis is an inflammatory condition which causes pain and stiffness in the heal and medial arch of the plantar surface of the foot. It is most common in the middle age group and among those participating in running sports. Phonophoresis and Myofascial release has been used in physiotherapy individually for treatment of plantar fasciitis and proved effective in reducing pain and improve functional status of patient. The study proposed to compare the efficacy of phonophoresis and myofascial release to treat plantar fasciitis.
Method: 30 subjects were divided equally into two groups each containing 15 subjects of both sexes. The group A received phonophoresis treatment and the group B received myofascial release treatment. The data was collected from all the patients on 1st day and on the 10th day of intervention by using two parameters, VAS and FFI.
Result: This study shows significant difference between groups i.e., group A (Phonophoresis) and group B (Myofascial release). The mean±SD VAS for group A was 4.80±0.94 while that for group B was 3.93±1.09 with p value (< .041) and the mean±SD FFI for group A was 0.44±0.09 while that for group B was 0.31±0.17 with pvalue (< .015) showed statistically significant difference between the groups.
Conclusion: Based on this outcome Phonophoresis is found to be more effective in reducing pain and improve functional status of the patient when compared with the Myofascial release in subjects with plantar fasciitis.

Keywords: Plantar fasciitis, phonophoresis, myofascial release, VAS scale, foot function index

1. Introduction
The term "Plantar fasciitis" defined as an inflammatory condition that occurs as a result of overstressing the plantar fascia [1]. In 1812, Wood described, Plantar fasciitis which has been referred to by various synonyms, heel pain syndrome, sub calcaneal pain syndrome, calcaneodynia, sub calcaneal bursitis, calcaneal periostitis, neuritis, heel spur syndrome, sub calcaneal spur syndrome, medial arch sprain, stone bruise, jogger's runner's heel, runner's heel, and policeman's heel [2].
An incredible 10% of the world's population will experience the condition during their lifetime [3]. The plantar aponeurosis is a thick fibrous band of connective tissue which originates at the medial and lateral tuberosities of the calcaneum. It runs longitudinally and has 3 portions, medial, central, and lateral. At the midfoot, the fascia divides into 5 different bands, which blend with the flexor tendon sheaths and transverse metatarsal ligament, attaches at the base of each proximal phalanx.
The clinical features of plantar fasciitis are pain on the sole of foot at the inferior region of the heel, pain to be particularly bad with the first step taken on rising in the morning or after an extended refrain from weight bearing activity [4].
The middle age people of 40 to 60 are more prone to plantar fasciitis [5]. Functions of plantar fasciitis are maintaining the medial longitudinal arch of the foot, and assists during the gait cycle and facilitates shock absorption during weight bearing activities [6].
Plantar fascia is not elastic and hence cannot stretch, when the forces on the foot is too great the arch flattens. Because of this, the plantar fascia begins to separate from its weakest point of attachment, often the heel bone(calcaneum) resulting in pain and inflammation that is distinct and treatable [7].

Types of plantar fasciitis

The four recognized types of plantar fasciitis are systemic, traumatic, degenerative, and mechanical (overuse).

The mechanical or overuse type of plantar fasciitis is caused by excessive pronation, which results in micro tears of the plantar fascia. The patient history almost always indicate a change in their level of activity, whether it be a dramatic increase in running mileage over a short period or a change in the level of activity at work [8].

The most common mechanical cause is excessive pronation of foot, which increases the stress to the plantar fascia along with surrounding intrinsic muscles. Increased stress is also placed on the calcaneal insertion of the plantar fascia, as a result of the excessive foot pronation. A bony hypertrophy of the medial plantar tubercle can occasionally occur at the site of plantar fascia attachment, which is termed as heel spur [9].

In general, the mechanical and degenerative forms of plantar fasciitis are commonly referred for treatment. These two types of plantar fasciitis are often seen in patients participating in endurance sports, in occupation requiring prolonged standing or walking, or with increases in normal levels of physical activity. These patients often complains of severe heel pain first thing in the morning after an hour of activity [8].

Pathomechanics

The plantar fascia is tractioned tight over the plantar surface of the base of the toes during the toe off. Due to the limited elasticity of the fascia, the arch is slightly raised, creating the rigid lever to apply the results of the forceful gastrocnemius contraction. This is called as "Windlass effect" [10].

The plantar fascia is an important static support for the longitudinal arch exerts its maximal pull on the plantar fascia, especially its origin on the medial process on the calcaneal tuberosity. The fascia elongates with increased loads to act as a shock absorber, but its ability to elongate is limited [11].

Problem usually arises with repetitive stress on the insertion of the plantar fascia. This leads to a pulling away of the fascia from the heel bone which causes inflammation and therefore pain. Injury may also occur at the sole or towards the toes.

When the fascia is pulled away from the bone, the body reacts by filling this space with new bone. This causes the classic heel spur. This heel spur is a side effect and not the cause of the problem [12].

Risk factors

- Sudden gain in body weight
- Unaccustomed walking or running
- Shoes with poor cushioning
- Increase in running distance and intensity
- Change in walking or running surface
- Tightness of Achilles tendon
- Occupation involving prolonged weight bearing [13].

Treatment for plantar fasciitis

1. Conservative treatment (electrotherapeutic modalities, patient education, soft tissue massage, acupuncture, taping, night splints, stretching, icing, heat, and strengthening) [14].
2. Extra – corporeal shock wave therapy
3. Injections and medication
4. Surgical interventions [15].

Myofascial release

Myofascial release is a soft tissue mobilization technique [16].

It utilizes the stretching of the fascia and muscle to increase ROM or to decrease pain by breaking up the adhesions in the fascia. Fascia is the connective tissue and is divided into three different layers. First layer is superficial fascia consisting the connective tissue and adipose tissue. It provides a path for nerve and blood supply. Second layer is the potential space. This area can become inflamed, which shows that it can be injured or stretched with any type of injury. Final layer is deep layer and is dense connective tissue that covers all the muscles and organs of the body.

Breaking the adhesions between the fascia and muscle allows the muscle and fascia to move smoothly over each other and helps alleviate the problem [17].

By this release there is a change in the viscosity of ground substance to a fluid state which decreases the fascia's excessive pressure on the pain sensitive structure and restores proper alignment [18].

This is achieved by relaxing contracted muscles, increases the circulation, increases both the venous and lymphatic drainage, and stimulates the stretch reflex of muscles and overlying fascia [19].

Phonophoresis

Phonophoresis is the technique of movement of the drugs through skin into the subcutaneous tissues under the influence of ultrasound [20].

It acts as a fast, painless, non-invasive alteration to local injection [21-22].

The application of ultrasound waves to the skin increases the permeability of the skin and raises the temperature 7-9 of (4-5 ^{o}c.) up to 3 in (8 cm) below the skin's surface within the localized area. In phonophoresis, drugs are applied to the skin before ultrasound treatment. Ultrasound waves disrupt the lipid layer in the cell membrane of the skin cells on the surface of the body. These cells create the strongest barrier to drug penetration. Ultrasound creates a channel in the cell membrane which takes the drug through the barrier and deeper into the tissue [23].

Once the drug penetrates, it is likely to be dispersed in circulation which depends on the vascularity of the tissues and the ease with which the molecules of the drug can enter the blood vessels [20].

Pulsed ultrasound mode appears to be more beneficial than continuous. Patients will not experience heat build-up and this will allow stationary ultrasound head placement to drive drugs into the area of discomfort or dysfunction.

2. Methodology

Source of data

1. Padmashree Physiotherapy Clinic, Nagarabhavi, Bangalore.
2. Employees State Insurance Hospital, Rajajinagar, Bangalore.
3. K C General Hospital, Malleshwaram, Bangalore.

2.1 Sample selection

- Population – subjects with plantar fasciitis.
- Sample size – 30 subjects.

Groups: Two groups

Group A: Phonophoresis 15 patients

Group B: Myofascial release 15 patients

- Sampling design – Simple random sampling.
- Study design: Comparative study with Pre-test to Post-test design.

A sample of 30 patients was assigned randomly into group A (phonophoresis and conventional therapy) N=15 and group B

(myofascial release and conventional therapy) N=15 in 35-55 years age group. Samples were randomly chosen from the outpatient department observing the inclusion and exclusion criteria. A qualified orthopaedician diagnosed them having plantar fasciitis. Patients were assessed by the use of an assessment Performa.

2.2a inclusion criteria
1. Plantar fasciitis due to mechanical pain.
2. Patient between ages of 35-55yrs of both genders.
3. Patients with heel pain felt on the first step in the morning, weight bearing, after walking and running.
4. Patients suffering from plantar fasciitis for last one and half months.

2.2b Exclusion criteria
1. Infective conditions of foot, tumour, calcaneal fracture, metal implant around ankle.
2. Dermatitis.
3. Impaired circulation to lower extremities.
4. Corticosteroid injection within a year to calcaneum.
5. Diagnosed with calcaneal spur.
6. Rheumatoid arthritis.

Duration: The duration of the treatment session is 10 days.

2.2c Parameters: Assessment was conducted on the first day and the last day of the treatment session by using the following parameters.
a. Foot function index [24].
b. Visual analog scale [25].

Foot function index: It is a questionnaire that has 12 questions related to pain affected different functions and activities. Pain severity was measured using a similar scale, 10 representing severe pain or inability to function. Visual analog scale: A horizontal scale of one to ten on which subject were made to grade the intensity of pain. A 10cm scale with 0 to 10 marking was drawn and subjects were asked to show mark on scale which defines the level of pain [20].

Procedure
An Ethical clearance was obtained from Ethical committee of Padma Shree Institute of Physiotherapy. Subjects who fulfil the inclusion criteria were included in the study. An informed consent was obtained from the subjects. The subjects were assigned into two groups, group A and group B by simple random sampling. Before the treatment initial pain level should be recorded by using VAS and Foot function index in both groups.
Position of subject: Phonophoresis – Prone position
Myofascial release – Supine position

Group A
Patients received Phonophoresis along with conventional fulfil gel was used in phonophoresis. Ultrasound was used with the output of 1 W/cm2 for 5 minutes and pulsed mode 1:4 ratio with frequency of 1 MHz for 10 sittings for 10 consecutive days [26].

Group B
Patients received Myofascial-release along with conventional treatment by using thumb, plantar cupping and fingers technique for 15 minutes [26]. Patient in supine lying with heel out of the couch. Therapist stands near the couch with one hand over the toes for stabilization and other hand moved down along the direction of fascia and the Myofascial stretch is held for 20sec, given slowly and subsequently feeling the tissues under the hands getting relaxed, the stretch is further increased and maintained for 90secs.

Conventional therapy includes
a. Contrast bath was given for 20 minutes for 10 days.
b. Exercises for intrinsic muscles strengthening
1. Towel curl up: patients sit with foot flat at one end of towel placed on a smooth surface, small weight is kept at the other end of towel. Keeping the heel on the floor, the towel is pulled towards the body by curling the towel with the toes, for 10 minutes.
2. Active ankle exercises: dorsiflexion, plantar flexion, inversion and eversion in supine lying 10 times.
3. TA stretching: Active stretching in standing by leaning against the wall, holding each stretch for 1 minute and repeating 5 times each session.
4. Plantar fascia stretching with tennis ball. Subject sitting on the chair rolling foot on the ball for 5 minutes [26].

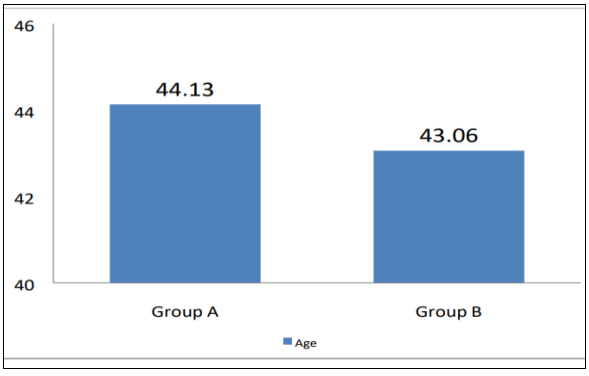
c. Interventions were given for ten days.
d. At the completion of tenth physical therapy sessions outcome measures were re-evaluated and pre and post scores were compared.

3. Results
A comparative study with 30 plantar fasciitis subjects out of which 15 were males and 15 were females randomized in 15 subjects in Phonophoresis and 15 subjects in Myofascial release is undertaken to study the effect based on VAS and Foot function index. All subjects fulfilled the inclusion and exclusion criteria.
Descriptive statistical analysis has been carried out by using SPSS version 17 in the present study and alpha value set at 0.05.
1. Unpaired t- test was used to test for age difference among both the groups.
2. Chi- square test was used to test for gender difference among both the groups.
3. Wilcoxon test was used to find out significant difference of VAS and FFI.
4. Mann Whitney U test was used to find out the significant difference in VAS and FFI between the groups.

Microsoft word and Excel have been used to generate graphs, tables etc.

Table 1: Baseline data of demographic variables

Sl.no	Variable	Group A	Group B	P value
1	Age	44.13±6.4	43.06±6.8	>.664
2	Sex (M/F)	6/9	9/6	>.273



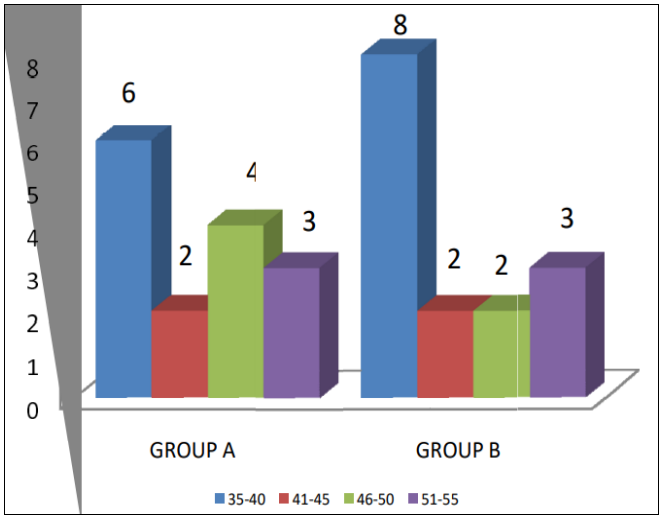
Graph 1: base line data for fdemographic variables

In the study group A mean age was 44.13 with a SD of 6.4

where in group B mean age was 43.06 with a SD of 6.8 and there was no significant defference among both groups (p value >0.664).

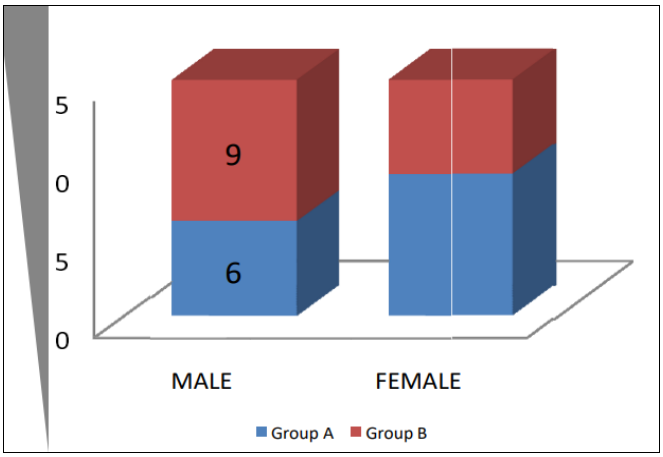
Table 2: Age distribution of subjects studied

Age in years	Group A		Group B	
	No	%	No	%
35-40	6	40	8	53
41-45	2	13	2	13
46-50	4	27	2	13
51-55	3	20	3	20
Total	15	100	15	100



Graph 2a: Age distribution of subject studied

In group A there were 6 subjects in 35-40 age group, 2 subjects in 41-45 age group, 4 subjects in 46.50 age group, 3 subjects in 51.55 age group. In group B there were 8 subjects in 35.40 age group, 2 subjects in 41.45 age group, 2 subjects in 46.50 age group. 3 subjects in 51.55 age group.



Graph 2b: Gender distribution of subject studied

There were 6 males and 9 females in group A and 9 males and 6 females in group B and difference was not statistically significant (p value >0.273).

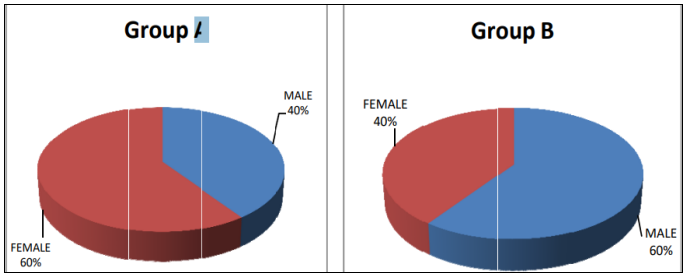
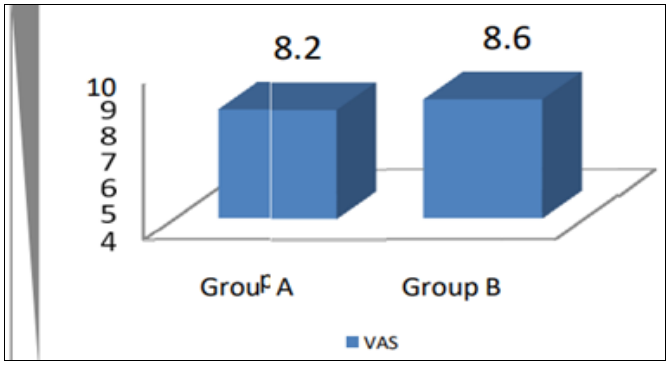
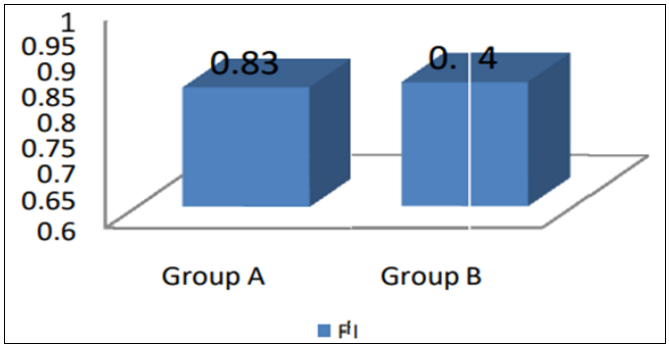


Table 3: Baseline data for outcome variables

Sl.no	Variable	Group A	Group B	P value
1	VAS	8.20±0.86	8.60±0.73	>.250
2	FFI	0.83±0.3	0.84±0.8	>.250



Graph 3: Comparison of VAS between two groups



Graph 3: Comparison of FFI between two groups

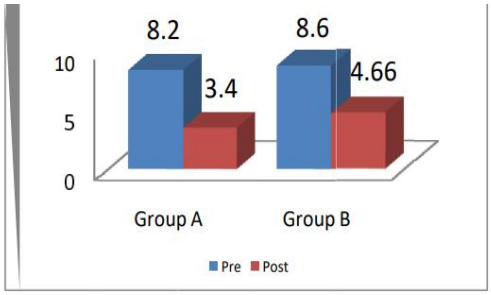
Data are mean (SD): p value are comparison of groups at baseline. The mean VAS was 8.2 with SD=0.86 in group A and the mean VAS was 8.6 with SD=0.73in group B. The mean FFI was 0.83 with SD=0.3 and the mean FFI was 0.84 with SD=0.8 and there was no significant difference among both groups (p value >0.250).

Table 4: Effect phonophoresis and conventional therapy on VAS and FFI

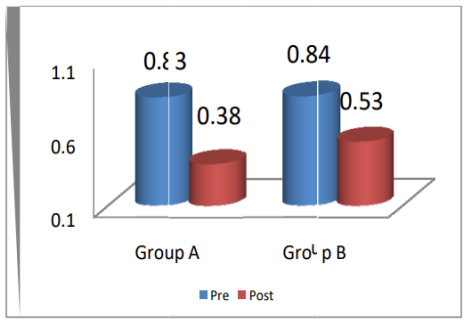
Sl.no	Variable	Pre	Post	P value
1	VAS	8.20±0.86	3.4±0.50	<.001
2	FFI	0.83±0.3	0.38±0.1	<.001

Table 5: Effect MFR and conventional therapy on VAS and FFI

Sl.no	Variable	Pre	Post	P value
1	VAS	8.60±0.73	4.66±1.1	<.001
2	FFI	0.84±0.8	0.53±0.15	<.001



Graph 4 : Comparison of VAS with in the groups



Graph 5 : Comparison of FFI with in the groups

Data are mean (SD) ; P value are comparison with in the two groups.

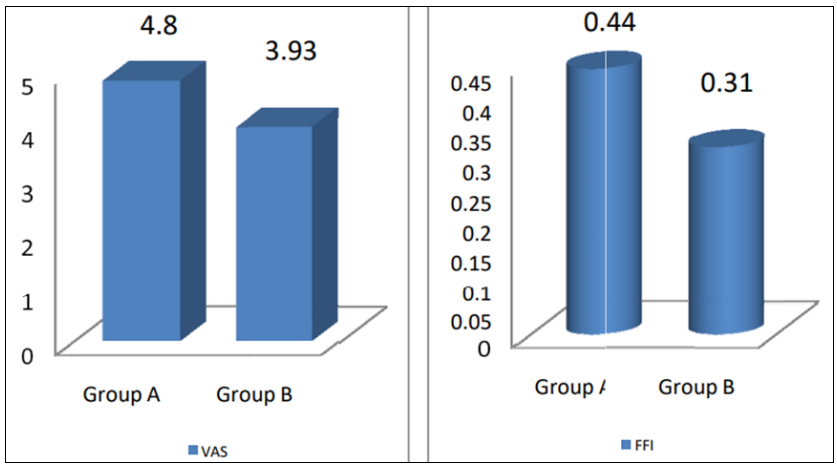
The pre mean score of VAS was 8.20 with SD=0.86 and the post score was 3.4 with SD=0.50 in group A and the difference is statistically significant (p value<.001).The pre mean score of VAS was 8.60 with SD=0.73 and the post score was 4.66 with SD=1.1 in group B and the difference is statistically significant (p value<.001).

Data are mean (SD) ; P value are comparison with in the two groups.

The pre mean score of FFI was 0.83 with SD=0.3 and the post score was 0.38 with SD=0.1 in group A and the difference is statistically significant (p value<.001). The pre mean score of FFI was 0.84 with SD=0.8 and the post score was 0.53 with SD=0.15 in group B and the difference is statistically significant (p value<.001).

Table 6: Difference between groups

Sl.no	Variable	Group A	Group B	P value
1	VAS	4.80±0.94	3.93±1.09	<.041
2	FFI	0.44±0.09	0.31±0.17	<.015



Graph 6: Difference between groups

Data are mean (SD): p value are comparison between the two groups. The mean score of gain in improvement in VAS is 4.80 with SD=0.94 in group A and mean 3.93 with SD=1.09 in group B which is statistically significant (*p* value<.015).

4. Discussion

Plantar fasciitis can be treated by various treatment techniques. Studies have been done on individual treatment and proved effective in reducing pain.

Phonophoresis and Myofascial release were proved effective in reducing pain individually. The study compared the effectiveness of 2 treatment strategies techniques in subjects with plantar fasciitis, appeared that Phonophoresis was effective than Myofascial release in decreasing pain and subjects showed clinically significant improvement.

In group A treated with Phonophoresis mean VAS score reduced from 8.20 to 3.4 with the p value (<.001) showed statistically significant improvement. The mean FFI score reduced from 0.83 to 0.38 with the p value (<.001) showed statistically significant improvement. This improvement is in accordance with a study done by Odjel who found out that Phonophoresis is more efficient in reducing pain at rest and in motion [27]. Yuch-Ling Hsieh concluded that pain relief in phonophoresis may be due to an effect on the central mechanism of nociception. The peripheral influences of US and phonophoresis on the central modulation of the spinal nociceptive processing system are important and may reflect the work being done through the neuroplasticity of spinal cord in response to peripheral input of US and phonophoresis [28].

Bommanan described that phonophoresis cause an increase in local temperature which causes an increase in the cell membrane permeability [29].

Nancy N Byl described that phonophoresis increases the

kinetic energy of the molecules in the drug and in the cell membrane, dilates points of entry such as the [30] hair follicles and the sweat glands and increases the circulation to the area sonicated.

These physiological changes enhance the opportunity for drug molecules to diffuse through the stratum corneum and be collected by the capillary network in the dermis.

The mechanical characteristics of the sound wave also enhance drug diffusion by oscillating the cells at high speed, changing the resting potential of the cell membrane and potentially disrupting the cell membrane of some of the cells in the area. The radiation or streaming forces are forceful to push drug molecules into the tissue [31].

Ciccone demonstrated that the induced drug may have reduced the formation of prostaglandin through the inactivation of cyclooxygenase (an enzyme that converts fatty acid into interstitial swelling) which may have reduced the inflammation at the teno periosteal junction there by reducing the pain [32].

In group B treated by Myofascial release shown mean VAS score reduced from 8.60 to 4.66 with the p value (<.001) showed statistically significant improvement. The mean FFI score reduced from 0.84 to 0.53 with the p value (<.001) showed statistically significant improvement. This is in accordance with a study done by Suman kuhar, who found out that Myofascial release is an effective therapeutic option in the treatment of plantar fasciitis. The pain is reduced as there is change in viscosity the ground substance to a more fluid state which eliminates the fascia's excessive pressure on the pain sensitive structure and restores proper alignment and there is increase in circulation and increase in venous and lymphatic drainage [26].

However, the statistics shows significant difference between groups i.e., groups A (Phonophoresis) and group B (Myofascial release). The mean ± SD VAS for group A was 4.80±0.94 while that for group B was 3.93±1.09 with p value (<.041) and the mean ± SD FFI for group A was 0.44±0.09 while that for group B was 0.31±0.17 with p value (<.015) showed statistically significant difference between the groups. The study showed the result where Phonophoresis was found to be more effective in reducing pain when compared with the Myofascial release in subjects with plantar fasciitis.

5. Conclusion

It can be assumed that both Phonophoresis and Myofascial release is effective in reducing pain. But the outcome of this study with significant statistical improvement seen in Phonophoresis on the outcome variables than Myofascial release will lead us to the conclusion of accepting the experimental hypothesis which could be stated as Phonophoresis is effective in reducing pain than Myofascial release.

As there is statistically significant difference between phonophoresis and myofascial release therapy the experimental hypothesis is accepted.

The study could be concluded as "There is significant difference produced in the phonophoresis than myofascial therapy in reducing pain in subjects with plantar fasciitis."

6. Limitations

1. The follow-up to see the long-term effects of these techniques is not done.
2. Our sample size was small, and data were collected at few outpatients' hospital and clinic, limiting the generalizability of the findings.
3. The study is of short-term duration

7. References

1. Tisdel CL, Donley BG, Sferra JJ. Diagnosing and treating plantar fasciitis: A conservative approach to plantar heel pain. Cleve Clin J Med. 1999;66:231-235.
2. Ahmad H. Alghadir. conservative treatment of plantar fasciitis with dorsiflexion night splints and medial arch supports: a prospective randomized study. 2006.
3. Heal Your Heel Pain » incidence of plantar fasciitis.2008.
4. Simon J. Bartold. Plantar heel pain syndrome: overview and management. Journal of Bodywork and Movement Therapies. 2004;214-226.
5. Douglas Richie. Plantar fasciitis: treatments pearls. American academy of podiatricsports medicine.2009.
6. Mario Roxas, ND. Plantar fasciitis: Diagnosis and Therapeutic Considerations. Alternative Medicine Review 2005;10(2):83-93.
7. Huang CK, *et al*. Biomechanical evaluation of longitudinal arch stability. Foot and Ankle International. 1993;14(6):353-357.
8. K Wong PK *et al*. Plantar fasciitis. Clinical sports med 1988;7:119.
9. Doxey G. Calcaneal pain: A review of various disorders, Journal of orthopaedicsports physical therapy. 1987;9:25.
10. Ambrosuis H, Kondracki MP. plantar fasciitis: European journal ofchiropractic 40:29.40
11. Noyes FE, Demaion, Mangne RE: orthopedics;1993.
12. Brochure. Plantar fasciitis. Milton physiotherapy and sports injury clinics.
13. Dishan Singh, John Angel, George Bently, Saul G Trevino. Fortnightly review:plantar fasciitis. BMJ. 1997 July 19;172-175.
14. Roxas M. Plantar Fasciitis: diagnosis and therapeutic considerations. Alternative medicine review jun. 2000;10(2):83-93.
15. Snider MP, MD Clascy WG MD, AA Mc Beath, MD. Plantar fascia release for chronic plantar fasciitis in runners. The American Journal of Sports Medicine. 1983;11:215-219.
16. Barnes, J F. Mind and Body Bioenergy of healing, PT and OT Today, 1996 Nov.
17. Anderson JC. Stretching Before and After Exersice: Effect on Muscle Sourness and Injury Risk. Journal of Athletic Training. 2005;40:248-255.
18. Travell J. Simons. Myofascial pain and dysfunction. The trigger point manual. Williams & Willkins. Baltimore. 1983, 1.
19. DiGiovanna Eileen. Stanley Schiowitz, Dennis J. Dowling [1991]. Myofascial (Soft Tissue) Techniques (Chapter 12). An Osteopathic Approach to Diagnosis and Treatment (Third ed.). Philadelphia, PA: Lippincott Williams & Wilkins. 2005, p. 80-82.
20. Jagmohan Singh. Text book of Electrotherapy.2005.
21. Quillen WS. Phonophoresis: A Review of the Literature and Technique,Athletic Training. 1980;15:109-110.
22. Pottenger FJ. Utilization of hydrocortisone phonophoresis in US Army physicaltherapy clinics. Mil Med. 1989;154:355-358.
23. Meidan VM, Michniak BB. Emerging Technologies in Transdermal Theraputics. American Journal of Therapy. 2004 July-August;4:312-316.
24. Michael Devitt. Electroaupuncture for plantar fasciitis. Acupuncture today. 2001 dec.

25. Anne M Boonstra, Henrica R Schiphorst, Preuper Michiel F Reneman, Jitze B Posthumus, Roy E Stewart. International journal of rehabilitation research. Internationale Zeitschrift für Rehabilitationsforschung. Revue internationale de recherches de réadaptation. 01/07/2008;31(2):165.
26. Suman Kuhar, Khatri Subhash, Jeba Chitra. Effectiveness of Myofascial Release in Treatment of Plantar Fasciitis: A RCT. 2007-07 - 2007-09, 1(3).
27. Odjel za fizikalnu medicine, rehabilitaciju i reumatologiju, Klinicka bolnica Split, Marmontova. Comparative study of the efficacy of ultrasound and sonophoresis in the treatment of painful shoulder syndrome. 1999;46(1):5-11.
28. Hsieh YL. Effects of ultrasound and diclofenac phonophoresis on inflammatory pain relief: suppression of inducible nitric oxide synthase in arthritic rats. 2006 Jan;86(1):39-49.
29. Bommanan D, Mennon GK, Okuyama H, Elias PM, Guy RH.Phonophoresis: II. Examination of the mechanism(s) of ultrasound enhanced transdermal drug delivery. Pharm. Res. 1992:9;1043-1047.
30. Klaiman MD, Shrader JA, Danoff JV, Hicks JE, Pesce WJ. Ferland Phonophoresis versus ultrasound in the treatment of common musculoskeletal conditions.1998.
31. Nancy N Byl**.** The use of Ultrasound as an Enhancer for Transcutaneous Drug Delivery: Phonophoresis. Physical therapy.1995, 75(6).
32. Charles D Ciccone, Brian G Leggin, John J Callamaro. Effects of Ultrasound and Trolamine Salicylate Phonophoresis on Delayed-Onset Muscle Soreness. 1991 September;71(9):666-675.