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Evidence Based use of Heat, Cold and NSAIDS for Plantar Fasciitis

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Abstract

Plantar Fasciitis is a possible complication in runners and even people who walk a lot. There have been numerous proposed therapies to treat this disorder but the independent effect of heat, cold and NSAIDS have not been examined without the concomitant use of other modalities. Here we examined the effect of heat, cold and Advil independently of other therapies on plantar fasciitis.

Objective: Subjects with plantar fasciitis either had no intervention, cold applied 20 minutes at night before bed, or 20 minutes in the morning upon wakening or either moist heat at night or in the morning (1 hour) or dry heat (4 hours) at night for 1 day or 3 days with and without Advil. Plantar fascia swelling, tenderness and pain were evaluated.

Methods: Visual analog pain scale, plantar facial thickness was measured by ultrasound as a measure of inflammation, the pressure tolerated by force on the plantar fascia from an algometer were measured first thing in the morning. An activity of Daily Living Subscale of the Foot and Ankle Ability Measure (FAAM-ADL) questionnaire was used for assessing disability. There were 99 subjects in 9 groups. All post intervention measurements were taken first thing in the morning before activity.

Results: The greatest relief of symptoms was with the application of cold used at bedtime the night before the measurements, cold used in the morning was not as effective as was heat. Cold use reduced the thickness of the plantar fascia and pain. Cold plus Ibuprofen were significantly better at reducing plantar fascia symptoms than cold alone. Conclusion: Cold applied for 20 minutes prior bedtime was the most effective treatment for reduced symptomology caused by plantar fascia inflammation. Advil further reduces pain when used with cold.

Keywords: Cold temperature; Plantar fasciitis; Pain; Foot; Therapeutics

Introduction

Plantar fasciitis is a common condition and can occur as a single occurrence or repeatedly throughout life [1,2]. It is most common in people who exercise frequently or especially in people with a high BMI or in the elderly [1,3,4]. The plantar fascia is a thick fibrous connective tissue which originates at the medial tuberosity of the calcaneus and inserts into the proximal phalanges [5,6]. The central portion is the thickest, attaches at the posterior aspect of the medial tuberosity of the calcaneus posterior to the origin of the flexor digitorum brevis tendon, and is 1.5 to 2.0 cm in width, distally, at the level of the metatarso-phalangeal joints. The central portion of the plantar aponeurosis divides into five fascicles, one for each of the toes [5,7]. The lateral portion of the plantar aponeurosis arises from the lateral aspect of the medial tuberosity of the calcaneus and its distal medial and lateral bands attach to the plantar plate of the fourth toe and to the base of the fifth metatarsal respectively and is 1.0 to 1.5 cm in width. The medial portion of the plantar aponeurosis is thin and continuous medially with the dorsal fascia and laterally with the central portion of the plantar aponeurosis. Edema in the plantar fascia therefore affects movement in the foot by inhibiting normal tendon movement to flex and extend the foot especially when body weight is applied [6,7]. Many mixed modalities have been used to treat this disorder. These include custom orthotic devices [7], rest, ice baths [5,8], heat, and stretching [7]. Night splinting and corticosteroid injections have also been used [9]. Heat has been applied at night and in many cases has positive results but the results are unpredictable [10]. But heat and other modalities are never used alone and also include other therapeutic modalities. But even with these modalities, the inflammation can return and severely limit normal gait [11].

One problem with treatment is the lack of evidence basis in the modalities that are used for treatment. Treatment involves mixed modalities [11,12]. Usually a physician or physical therapist will manipulate the foot by stretching and apply heat or cold and use non-steroidal anti-inflammatories or steroids and orthotics [12-14]. In some cases, platelet rich plasma has been injected [6]. If inflammation and pain are resolved in a clinical setting, there is no way of knowing which modality resulted in improvement.

In the present investigation we used cold, heat or Advil as the only intervention for up to 3 days and measured plantar fascia inflammation, pain level, tolerance to pressure on the plantar surface, and a standardized functional assessment instrument. No other treatments such as stretching or range of motion or steroids were used the week before the subjects participated in this project. Two series of

experiments were undertaken. In the first, either heat or cold was used in an acute 1 day study where heat or cold were applied either the night before or morning before measurements. This led to the second series of experiments where cold and Advil were tested over a 3 day period to test their joint efficacy.

Subjects

Ninety nine subjects were recruited for this study in 2 series of experiments. In one group, cold and heat were used for a single treatment and the other cold was used in conjunction with an NSAID, Advil. Eligible subjects were required to meet all the following inclusion criteria: (1) subjects of both genders are diagnosed with plantar fasciitis; (2) subject's age is between 18-65 years; (3) duration of symptoms is less than 5 years; and, (4) plantar fascia thickness greater than 4 mm as assessed by imaging ultrasound. Exclusion criteria included: (1) previous fracture or surgery to the foot or (2) specific metabolic and connective tissue disorder associated with or contributing to the diagnosis of plantar fasciitis (PF). All purposes and procedures were approved by the Solutions Institutional Review Board and each patient signed a statement of informed consent. The demographics of the subjects are listed in Tables 1 and 2.

		Age (years)	Height (cm)	Weight (kg)	BMI	Faam
Control	**Mean**	51.9	155.2	85.4	29.4	30.2
	Standard deviation	3.6	26.5	15.8	4.2	8.5
Heat night	**Mean**	45.6	172.2	80.0	26.9	26.0
	Standard deviation	11.9	8.7	17.5	5.4	14.7
Moist night	**Mean**	46.6	176.6	86.8	27.7	23.2
	Standard deviation	6.4	12.7	17.7	4.3	13.2
Moist morning	**Mean**	42.8	167.3	80.3	28.7	23.8
	Standard deviation	9.0	3.8	15.3	5.2	16.9
Cold night	**Mean**	52.3	164.1	75.8	27.9	21.9
	Standard deviation	5.5	4.5	19.1	5.8	5.4
Cold morning	**Mean**	43.8	171.4	81.3	27.5	23.8
	Standard deviation	9.5	6.7	19.0	5.2	16.9

Table 1: General characteristics of 60 subjects in the series 1 experiment.

		Age (Years)	Height (Cm)	Weight (Kg)	BMI
Cold	**Mean**	39.1	163.9	74.5	27.4
	Standard deviation	12.3	9.2	21.4	5.1
Cold + ibuprofen	**Mean**	38.1	160.8	76.4	26.6
	Standard deviation	10.1	7.5	24.4	10.6
Sham	**Mean**	44.2	164.9	86.8	29.3
	Standard deviation	17.6	5.8	26.9	13.3

Table 2: General characteristics of 39 subjects in the series 2 experiment.

Methods

Visual analogue scale

A visual analogue scale (VAS) was used to measure heel pain. It was a numerical scale 10 cm long where 0 indicated no pain, and 10 indicated the worst pain ever. The patient self-rated his/her foot pain based on his/her first steps in the morning, by placing a mark on the line representing his/her level of pain. This scale has been established as a reliable and valid instrument to measure acute and chronic pain [15].

Pressure algometer

A handheld pressure algometer was used to measure the heel tenderness threshold. Tenderness threshold was defined as the minimum pressure or force that produces pain. A pressure algometer is a force gauge fitted with a hard rubber tip and calibrated in N/cm^2 (Wagner Inc, Greenwhich Conn). To assess tenderness, the principal investigator first placed the patient in a supine position with legs fully extended and palpated and marked the tender point over the plantar fascia at the medial calcaneal tubercle. He then dorsiflexed the ankle and toes passively and applied the algometer over the mark placed on

the medial calcaneal tubercle. The algometer contact head was aligned perpendicularly to the skin and the principal investigator gradually increased the algometer pressure until the patient reported pain. The algometer reading, which represented the pressure needed to elicit pain (in Newton per square centimeter), was recorded. Higher algometer scores indicated greater pressure tolerance and, hence, less tenderness. Lower algometer scores indicated less pressure tolerance and, thus, greater tenderness. The reliability and validity of pressure algometer as a measure of tenderness has been documented in the literature.

Foot and ankle ability pain in activities of daily living

To assess functional activities levels, the subjects were asked to record their ability to perform daily activities using the Activities of Daily Living subscale of the Foot and Ankle Ability Measure (ADL/FAAM) [16]. The ADL/FAAM identifies 21 daily activities, and participants rated their ability to complete each activity based on a scale ranging from no difficulty to inability to complete. Individual participant responses to the ADL/FAAM questions were converted to numerical scores using a 5-point scale, with scale ranging from 0 " no difficulty" to 4 "unable to do," certain daily activity. Thus a lower ADL/FAAM score indicates a higher functional activity level. FAAM is a self-reported instrument specific to those with lower leg musculoskeletal disorders. FAAM is a reliable, valid, and responsive self-reported instrument for assessing the activity and function level for patients with lower leg musculoskeletal disorders.

Ultrasound

Musculoskeletal ultrasound (US) is a useful imaging tool in confirming a diagnosis of plantar fasciitis by measuring plantar fascia thickness before and after a given treatment regimen to gauge the treatment's efficacy. The standard "normal" or asymptomatic thickness value reported for the plantar fascia is 2.3 to 4.0 mm, averaging 3.4 mm. It is accepted that a thickness of greater than 4 mm would be consistent with plantar fasciitis. Each involved foot was evaluated sonographically with a L14-6 MHz linear array transducer (Mindray-M7 Diagnostic Ultrasound System, Shenzhen, P. R. China) and acoustic coupling gel applied to the plantar surface of the foot. The plantar fascia is best examined with the patient in the prone position, with the affected foot hanging over the edge of the examination table with his or her ankle in neutral position. The ultrasound probe was applied vertically to the plantar aspect of the heel. The sagittal thickness of the proximal insertion of the plantar fascia was measured, at a standard reference point 5 mm from the proximal insertion at the anterior aspect of the inferior border of the calcaneus. A typical picture is shown in Figure 1.

Applying heat and cold to the foot

Heat was applied by 2 different methods, with ThermaCare heat wraps (duration 4 hours) or ThermaCare moist heat wraps (duration 1 hour) (Pfizer Pharmaceuticals, Madison New Jersey). Cold was applied by a ThermaCare cold wrap for duration of 20 minutes.
Ibuprofen- 400 mg Ibuprofen was dosed every 6 hours for TDD 1200 mg (per day) for 3 days.

Procedures

The baseline evaluation included the measurement of: (1) heel pain with the Visual Analogue Scale (VAS); (2) heel tenderness with the pressure algometer; (3) disability level; and, (4) sagittal thickness of proximal plantar fascia.

Series 1- The subjects were assigned to one of 6 groups. One group was the control and only measurements were taken 2 days apart. The pre and post evaluation included: (1) heel pain; (2) heel tenderness; (3) disability level using Activities of Daily Living Subscale of the Foot and Ankle Ability Measure (ADL/FAAM); and, (4) sagittal thickness of proximal plantar fascia by ultrasound. For the other 5 groups, the same measures were used but an intervention was done between the measures. In different groups, cold was used either the night before or at wakening (20 minutes) , moist heat was used the night before or at wakening (1 hour) and dry heat was used the night (4 hours) before the final measurement.

Series 2- The subjects were assigned randomly to one of 3 groups. The pre and post evaluations at days 1,2 and 3 post cold included: (1) heel pain; (2) heel tenderness; (3) disability level using Activities of Daily Living Subscale of the Foot and Ankle Ability Measure (ADL/FAAM); and, (4) sagittal thickness of proximal plantar fascia with the ultrasound transducer. For the 3 groups, the same measures were taken but an intervention will be done between the measures. The groups were cold at night for 1,2 and 3 days or cold at night for 1,2 and 3 days, plus Ibuprofen for 1,2 and 3 days, or sham heat and sham Ibuprofen for 1,2 or 3 days. No physical therapy modalities such as stretching or iontophoresis were used over this time or 1 week before.

Data analysis

Analysis of variance (mixed factorial ANOVA) test was used to determine if significant differences exist among the groups in terms of pain, tenderness, ADL, and fascia thickness. The level of significance was set at $p<0.05$.

Results

Series 1: Measures of plantar fascia thickness were made 5mm from the calcaneus and then the full thickness width was measured. A typical subject is shown in Figure 1. The greatest reduction in pain (Figure 2) and in thickness of the plantar fascia (Figure 3) was with cold applied at bedtime. Heat actually caused an increase in plantar thickness as shown in Figure 3.

As shown in Figure 2, cold applied at night before bed clearly produced the greatest reduction in pain the next morning. Cold at night and in the morning were significantly better than that seen for the control subjects ($p<0.01$). The control data was not significantly different in the first and second measurements. ($p>0.05$) Heat and moist heat all caused a significant reduction in pain ($p<0.05$). Heat at night was just as effective as cold in the morning and there was no significant difference between the 2 ($p>0.05$). Heat could not be applied in the morning due to the duration needed to apply it.

The pressure applied to the plantar fascia with the algometer almost doubled when cold was used at night and was over 40% higher for cold used in the morning. This showed better tolerance to pressure applied to the sore area. For both cold groups the increase in pressure was significant ($p<0.01$). There was no difference in the algometer data pre vs. post in the control group. (Figure 4) Moist heat increased the pressure that could be applied with the algometer ($p<0.05$) but heat did not ($p>0.05$).

Figure 1: A typical subject before modalities.

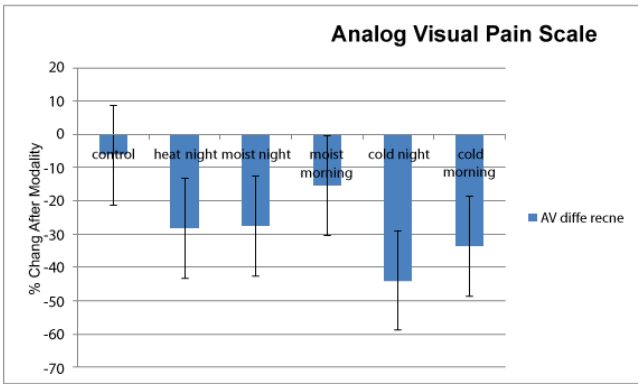

Figure 2: Percent change in the analog visual pain scale from the first to the second day after application of each modality. The data is the mean of 10 subjects +/- the SD.

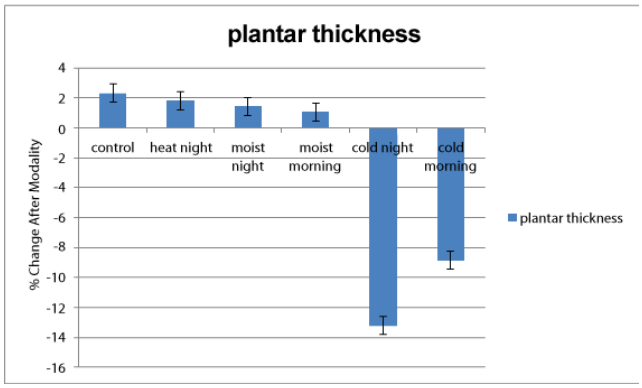

Figure 3: Change in plantar fascia thickness pre and post modality. The data is the mean of 10 subjects +/- the SD.

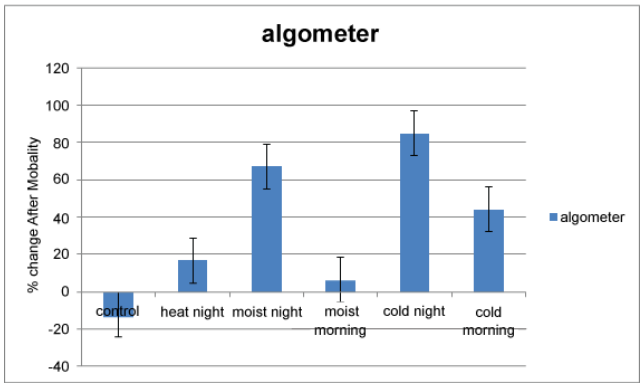

Figure 4: the change in algometer pressure for perception of pain before and after each modality in 10 subjects +/- the SD.

Series 2- Based on the series 1 experiments, only cold was tested in series 2 since this was the best modality of those we tested. It was tested for 3 days with and without Advil to see if an anti-inflammatory plus cold would have a better effect.

Analog Visual Pain Scale

The results of the analog visual pain scale on the 3 groups of subjects are shown in Figure 5.

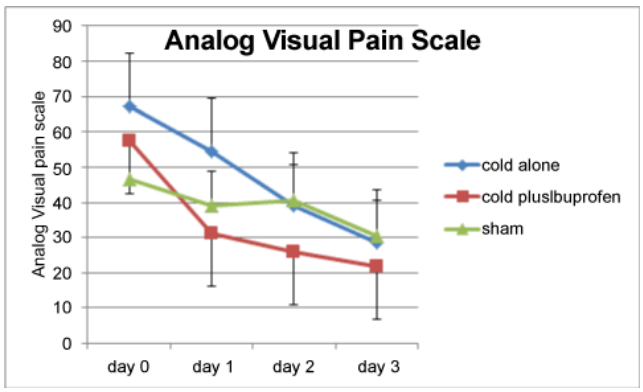

Figure 5: The average analog visual pain scale over the 4 days in the 3 groups of subjects. Each point is the mean +/- the SD.

As shown in Figure 5, for the cold alone group, there was a steady reduction in pain each day that cold was applied and therapy was used. The average reduction over the 4 days was 57.6+/-17.2% reduction in pain. This reduction in pain was significant ($p<0.01$). For the cold plus Ibuprofen group, there was no difference in pain in the foot at the start of the study compared to the cold group ($p>0.05$). The first and second day after the study started, pain was significantly less in the Ibuprofen plus cold group ($p<0.05$) but by the last day, pain was not significantly different in the groups of subjects ($p>0.05$). For the sham group, the heal pain was not different at the start of the study between this group and the other 2 groups of subjects ($p>0.05$). There was no significant difference between the start and days 1 and 2 in this group but by the third day, heel pain had dropped by 17.1+/- 5.2%, a significant drop from the first day ($p<0.05$). As a percent reduction in pain, cold plus Ibuprofen was significantly greater than cold alone and both were better than sham treatment ($p<0.05$, ANOVA).

Algometer pain scale-

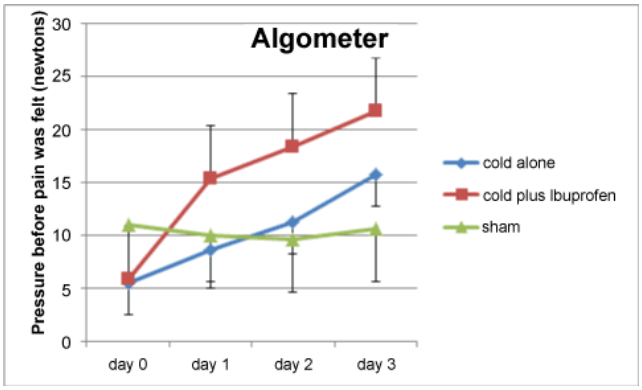

Figure 6: The average heal Algometer force where pain was felt over the 4 days in the 3 groups of subjects. Each point is the mean +/- the SD.

The results for the Algometer pain scale are shown in Figure 6. As shown here for the cold alone group, there was a large increase in the ability to tolerate pressure on the plantar fascia. This amounted to a 170+/- 34 % increase in the ability to tolerate pressure on the foot. For the Ibuprofen plus cold group, the pressure that could be tolerated at the start was the same as the cold group. However, the cold plus Ibuprofen group could tolerate significantly more pressure each day than the cold group ($p<0.01$), amounting to an increase in pressure tolerance of 275+/-34% increase. For the sham group, the increase in pressure tolerated by the algometer from the first to last day was small, 3.5%, but was significant compared to the control data in the same subjects ($p<0.05$). Comparing the three groups to each other, cold plus Ibuprofen showed the best increase in pressure tolerance followed by cold and then the sham group. The pressure on the 3rd day was significantly different among the groups ($p<0.01$).

Plantar Thickness

The results of the plantar thickness are shown in Figure 7. For the cold alone group and cold plus Ibuprofen group, there was a significant drop in plantar thickness ($p<0.01$) comparing the first to the last day. This amounted to a 16.5+/-4.7% reduction in thickness of the plantar fascia for the cold group and 15.8% reduction in thickness in the cold plus Ibuprofen group. There was no significant difference between these groups ($p>0.05$). For the sham group, the plantar fascia thickness actually increased over the 3 treatment days by 1.9%, a small and non-significant difference ($p>0.05$). There was no difference in the cold and cold plus Ibuprofen groups but both groups were significantly better than the sham group.

FAAM

The results of the FAAM are shown in Figure 8.

As shown in this figure, the FAAM was significantly increased after the 3 days use of cold ($p<0.01$). The average increase was 8.4% for the

cold and 18.7% for the cold plus Ibuprofen groups. There was no significant difference between the groups. The sham group showed an increase averaged 4.1% and was not significant compared to the resting value but there was no difference between the groups (p>0.05).

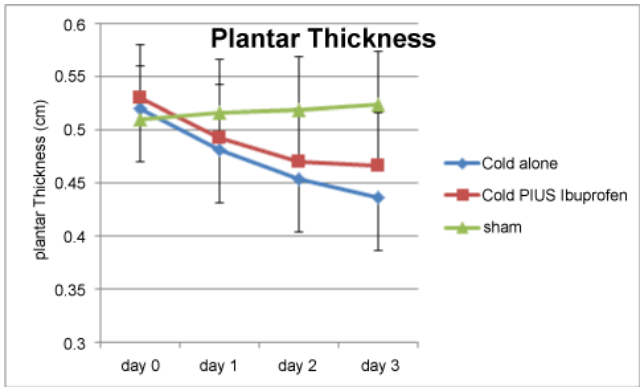

Figure 7: The average plantar thickness over the 4 days in the 3 groups of subjects. Each point is the mean +/- the SD.

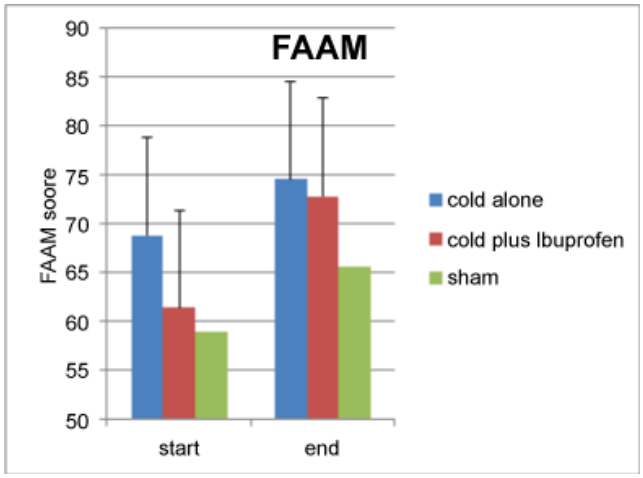

Figure 8: The average FAAM score over the 4 days in the 3 groups of subjects. Each point is the mean +/- the SD.

Discussion

Plantar fasciitis is a common disorder especially in runners [17]. Obesity, excessive foot pronation, excessive running, and prolonged standing are also risk factors for developing plantar fasciitis even in non-runners and non-athletes [7]. It can be diagnosed from ultrasound imaging of the plantar fascia if it is thicker than 4 mm [7]. Many different treatment modalities are used for this disorder. The most common treatment is stretching of the gastrocnemius and soleus muscles to loosen the plantar fascia [1,17]. Deep myofascial massage and iontophoresis is usually performed by a physical therapist and can help [2]. Orthotics commonly are used to keep pressure off of the plantar fascia [14]. NSAIDS have been reported to have excellent reductions in pain and inflammation [18]. Cold is used for treatment in some cases but papers showing efficacy are rare. Ice on the plantar fascia reduces sensation by blocking receptors [19]. It also reduces plantar swelling [20].

But in these studies, cold or heat were not used alone but in conjunction with other therapies, especially stretching. Here we looked at modalities alone. Clearly from the series 1 experiments, cold the night before measures of pain and inflammation was the clear winner. It reduced swelling and pain significantly. Cold in the morning worked but not nearly as well. Heat showed good results at night, especially moist heat. But heat applied at night in other studies has shown positive results but the results are sometimes unpredictable [10].

Therefore in the series 2 experiments, we used only cold at night but wanted to see if cold every night for 3 days would have a better effect. We also tested to see if Advil, an NSAID would work synergistically with cold. Here, for the cold only group, there was a 57.9% reduction in heal pain on the AV pain scale; a 170% reduction in the algometer pressure that could be tolerated, and plantar fascia thickness was reduced by 16.5%. Cold here was used for 3 repeated days. When cold and Ibuprofen were added, data was significantly better than the cold treatment and showed a considerable improvement in the pressure that could be tolerated by the algometer on the plantar fascia. To some extent this is not surprising since it shows that Ibuprofen is a good pain reducing analgesic and is synergistic with cold[21,22]. Ibuprofen works by moderate inhibition of COX-1 and COX-2 enzymes thereby inhibiting prostaglandin production in tissue. It therefore has benefits in reducing pain and inflammation [21,23]. Therefore it should have duel effects on plantar fasciitis; reducing swelling and reducing pain. The reduction in plantar fascia thickness was not greater with cold plus Ibuprofen; it would appear that the predominant effect on swelling here was cold while the effect of Ibuprofen alone was not studied. The visual analog pain scale did not improve better that that seen for cold alone but this is not surprising since they had no pressure on the plantar fascia when the pain scale was recorded vs. the algometer where pressure was applied to the plantar fascia. Here the 2 modalities together made a significant difference.

The best evidence for the efficacy of cold comes when comparing it to the sham cold and the sham Ibuprofen group. Here there was no change in plantar fascia thickness, a small reduction in pain but no change in pain related to applying pressure. Thus cold and cold plus Ibuprofen are good together to help plantar fasciitis. A problem with cold is that it has always been poorly defined in terms of what cold is and how long to apply it [24]. Sometimes it involves whole body immersion, contrast baths [25], or icing with the length of time modalities are applied quite variable [24,26]. Cooling causes a reflexive vasoconstriction of blood vessels, due to increased affinity of alpha-adrenergic receptors in cold blood vessels for norepinephrine in the vascular walls [27]. This should contribute to reducing inflammation. For the foot, where the plantar fascia is close to the surface, cold should be effective in penetrating in the 20 minute treatment period here with a gel cold pack at 32 degrees Fahrenheit [28,29]. Longer durations of cold at this temperature may cause tissue damage and less time may not penetrate to deep tissues well [29-32].

Ultimately, this study represents a small number of subjects. Further work is needed to see if multiple cold treatments may help and more days of cold treatments may be better.

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