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Far-infrared ray patches relieve pain and improve skin sensitivity in myofascial pain syndrome: A double-blind randomized controlled study

Yen-Ting Lai[a,b], Hsiang-Lin Chan[c], Shu-Huan Lin[a], Chih-Ching Lin[d,e], Szu-Yuan Li[d,e], Chih-Kuang Liu[f], Hao-Wei Teng[d,h], Wen-Sheng Liu[d,g,i,j,*]

[a] Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital Hsin-Chu Branch, Hsinchu, Taiwan
[b] Department of Nursing, Yuanpei University, Hsinchu, Taiwan
[c] Department of Child Psychiatry, Chang Gung Memorial Hospital and University, Taoyuan, Taiwan
[d] Faculty of Medicine, School of Medicine, National Yang-Ming University, Taipei, Taiwan
[e] Division of Nephrology, Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan
[f] College of medicine & Graduate institute of Business Administration, Fu Jen Catholic University, New Taipei City, Taiwan
[g] Division of Nephrology, Department of Medicine, Taipei City Hospital, Zhongxing Branch, Taipei, Taiwan
[h] Division of Hematology and Oncology, Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan
[i] Institute of Environmental and Occupational Health Sciences, School of Medicine, National Yang-Ming University, Taipei, Taiwan
[j] College of Science and Engineering, Fu Jen Catholic University, New Taipei City, Taiwan

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ABSTRACT

Objective: Myofascial pain syndrome (MPS) is a common disorder characterized by muscle pain if myofascial trigger points (MTrP) are stimulated. This study evaluated the effectiveness of far-infrared ray (FIR) patches in reducing the severity of pain in patients with MPS.

Methods: A double-blind, randomized controlled study involving 125 patients with MPS and 201 MTrPs located in the trapezius muscle. A FIR patch was applied to 98 MTrPs for 24 h in the intervention group (61 patients) and a placebo patch was applied to 91 MTrPs in the control group (57 patients) at the end. Pain intensity was measured using the visual analogue scale (V) while pressure pain threshold (P) and maximal pain tolerance (T) were measured using an algometer before and after treatment.

Results: The mean age of the patients was 37.16 years old and 67% were female. There was a positive correlation between P and T ($p < 0.001$). Older Age was associated with higher P and T due to poor skin sensitivity ($p < 0.001$). V improved significantly in both groups to a similar extent, but only in the intervention group, P and T decreased significantly (which implied better skin sensitivity) ($p < 0.05$). P and T decreased the most in the female group aged over 35, probably due to thinner skin in this subgroup.

Conclusions: FIR and placebo patches were equally effective at relieving pain (with decreased V), but P and T dropped only in the intervention group with FIR patches. This probably resulted from FIR penetrated only to the skin layer and improved skin sensitivity with more blood circulation, but the muscle remained unaffected. Further studies should investigate the effect of longer exposure or higher energy applications.

1. Introduction

Myofascial pain syndrome (MPS) is a common pain disorder responsible for many pain clinic visits. It is one of the most common causes of musculoskeletal pain, with an estimated prevalence of 12% in the general population.[1]

The characteristic physical finding of MPS is the presence of a myofascial trigger point (MTrP) on the taut band of skeletal muscle. Referred pain can be triggered and a local twitch response can be evoked if the MTrP is mechanically stimulated.[2] An MTrP is defined as being active if spontaneous pain occurs or as being latent if the pain occurs only when it is stimulated. Sensitive loci are sensitized nociceptors located in MTrP.[3] These points release more acetylcholine during relaxation, which causes the contraction of muscle fibers and the formation of a taut band. MTrPs also result in a reduction in pain threshold.

The diagnostic criteria for MTrP enabled the clinicians to make a more objective diagnosis of MPS,[4] including: (1) an hyperirritable tender spot, (2) recognition of pain on this spot, (3) taut band contained on this spot, and (4) referred pain and local twitch response when this

* Corresponding author at: Division of Nephrology, Department of Medicine,Taipei City Hospital, Zhongxing Branch, No.145, Zhengzhou Rd., Datong Dist., Taipei 103, Taiwan.
E-mail address: robertliu2001@yahoo.com (W.-S. Liu).

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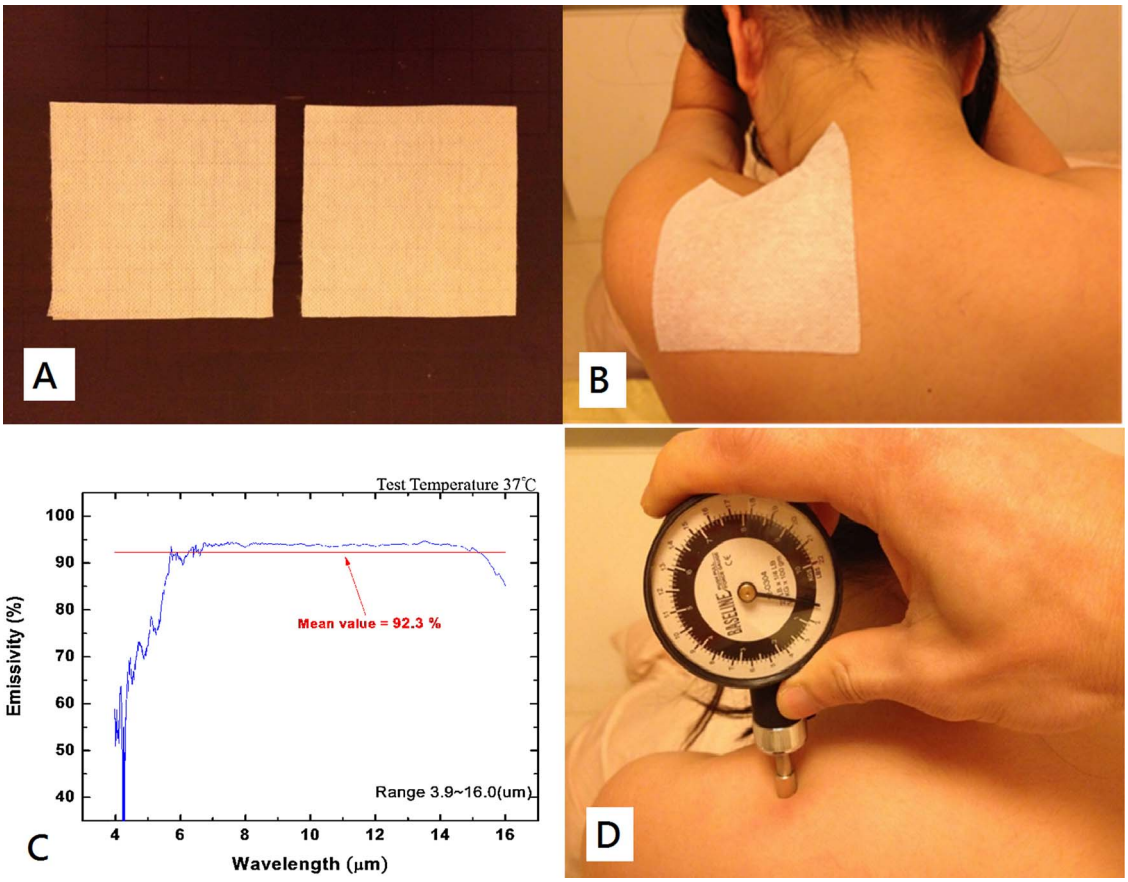

Fig. 1. A. The far infrared patch (left) and placebo patch (right) are identical in appearance. B. Patches are applied to the upper trapezius region of patients with myofascial pain syndrome (MPS). C. The energy analysis of the far infrared patch by Fourier Transform Infrared Spectroscopy. D. The algometer for measuring pressure pain threshold (P) and maximal pain tolerance (T) (Pain Diagnostics and Thermography Corporation, Model PTHAF2).

spot is stimulated. However, it is difficult to measure the sensitivity of MTrPs by imaging studies or blood flow tests.[5]

Previous study reported that abnormal endplate potential on the active loci is related to the excess acetylcholine released from neuromuscular junctions near MTrP.[6] Simons et al. proposed a theory of energy crisis to explain the etiology of MPS, in which the muscle tends to contract when overused or injured, thus impairing blood flow and energy storage which preventing entry of calcium into muscle cells.[4] The influx of calcium makes the muscle contract longer and induces more injury, which forms a vicious cycle.[7]

The primary goal of treatment for MPS is trigger point relaxation and pain relief. A number of noninvasive and invasive techniques are currently used to treat patients with the syndrome.

Thermotherapy, for example, is a noninvasive technique that has been shown to improve local blood circulation, relax the muscle and lower the muscle tension at MTrPs. The modality, however, puts patients at risk for burn injury and needs to be used with caution.[8] Transcutaneous electrical nerve stimulation (TENS) is another commonly used noninvasive treatment for MPS. The modality has been shown to increase the release of endorphins into the microcirculation and to modulate the autonomic nervous system. However, it provides only short-term pain relief and is not effective in all patients.[9]

Acupuncture and local injection of anesthetics at the MTrP are commonly used invasive techniques for treatment MPS.[8] Acupuncture mainly relieves pain and relaxes muscle by inducing a local twitch response through repeated puncturing at the MTrP locus. This technique, however, induces pain and increases the risk of complications such as infection, bleeding or pneumothorax.[10]

On the other hand, FIR therapy has been shown to be effective at improving blood circulation, while poor blood circulation may be the cause of energy crisis and muscle pain in MPS.[11,12] The infrared radiation can be divided into three categories by wave length: near-infrared radiation (0.8–1.5 μm), middle-infrared radiation (1.5–5.6 μm) and far-infrared (FIR) radiation (5.6–1000 μm).[12] FIR therapy can improve blood flow in skin and promotion wound healing with evidence in animal study and human clinical trial.[13,14] The Far-infrared patch (FIR) is on the market now and can be a safe and convenient solution to the above-mentioned disadvantages, such as safety concern or discomfort.[15] Patients can apply the patch by themselves without discomfort or danger. Patients can go to work with patch on them without being noticed. If FIR patch can treat MPS successfully, many patients including those who are physical disabled can also benefit from it. However, few studies have investigated the effectiveness of FIR at relieving pain in patients with MPS.[16] Lai et al. reported that although the FIR resulted in significant improvement in pain scores in patients with MPS, there was no significant difference in pain scores between the intervention and control groups. They also reported that only patches containing far-infrared emitting ceramic powder (cFIR) resulted in a significant decrease in degree of trapezius muscle stiffness in the intervention group.

The present study aims to evaluate whether application of the FIR patch at trigger points in the trapezius muscle is effective at reducing pain and increasing the pressure threshold and pain tolerance in patients with MPS.

2. Methods

2.1. Study population

All patients in this study were recruited from a large teaching

hospital in an urban area in the Northern Region of Taiwan. Inclusion criteria included age > 18 years and a diagnosis of MPS affecting the upper trapezius. All diagnoses were established by senior physiatrists with experience of more than 10 years.

Exclusion criteria included patients who were under rehabilitation or taking medications for pain relief, those with previous neck or shoulder operations, cervical spine radiculopathy, local skin wounds and patients who had difficulty following instructions because of mental or hearing impairment.

The study protocol was approved by the institutional review board and all patients provided written informed consent to participate. Institutional Review Board (IRB)/Ethics Committee approval was obtained before the trial began, and the study was conducted in full compliance with the Declaration of Helsinki.

2.2. Material

The FIR patch and the placebo patch were both 15 cm × 15 cm in size and had the same physical appearance (Fig. 1A). All patches were applied to the upper trapezius region (Fig. 1B). Fourier transform infrared (FTIR) spectroscopy was used to quantify the amount and intensity of radiation emitted by the FIR patch (Fig. 1C).

A spectrometer can measure the energy of FIR in each patch.[17] The spectrometer can detect the exact light energy at a certain wavelength (FIR wavelength 4–16 μm) in units of mw/cm^2 or mjw/cm^2, thereby providing a more accurate measurement of energy applied to patients. At a standard temperature of 37 °C, the spectrometric analysis revealed that FIR energy with wavelength between 3.9 μm–16.0 μm accounted for 92.3% of its total energy emitted from the FIR patch. The total output power of the patch was 0.038 w/cm^2. The experiment duration was 24 h. The total energy output is 15*15 cm^2 *0.038 (J/s)/cm^2 *24 h *3600(s/h) = 738,720 (J) (92.3% of the energy is in the form of FIR, which indicates 681,838 J)

2.3. Parameters

The parameters included 3 items: pain intensity calculated by the visual analogue scale (V), pressure pain threshold (P) and maximal pain tolerance (T). Both of last two items were measured with an algometer, a pressure detector used to measure pressure pain threshold (unit by kg/cm^2) with a tip of cork (one square centimeter in tip contact surface). Kinser et al. found this instrument has a good consistence of the results measured among different observers.[18]Algometry has been shown to be an accurate and reliable method for measuring the severity of pain at MTrPs in patients with MPS.[19]

The visual analogue scale is used to measure subjective characteristics which cannot be directly measured. When responding to a visual analogue scale item, participants specify their level of subjective feeling by indicating a position along a continuous line within two end-points. The reliability of the visual analogue scale for chronic pain is shown to be moderate to good in other study.[20] In this study, the visual analogue scale was a horizontal line measuring 10 cm in length anchored by two verbal descriptors, one for each symptom extreme. For pain intensity, the scale was anchored by “no pain” (score of 0) and “most severe pain ever experienced” (score of 10). Patients were asked to place a line perpendicular to the visual analogue scale line that best represents the intensity of their pain.

The P indicated the pressure given when the patient started to feel pain. The pressure was increased until it reached T, which indicated the pressure given when the patient could no longer tolerate it. Both were measured by a pressure algometer (Pain Diagnostics and Thermography Corporation, Model PTHAF2) (Fig. 1D) as reported by Fisher et al.[21] Doctors performed physical exam on patients and located the MTrP on the trapezius. After locating the MTrPs on the trapezius muscle, the algometer was applied to the point with force directed to the skin and the force was increased at a rate of 1 kg/cm^2/s. P and T were measured 3 times each at no less than 10-s intervals to obtain the mean values.

2.4. Protocol

A total of 125 patients fulfilled the inclusion criteria and were enrolled in this double-blind, randomized trial. Of the 201 trigger points detected among these 125 patients, 101 trigger points (62 patients) were exposed to FIR patches and 100 trigger points (63 patients) were exposed to placebo patches. Even-numbered trigger points were assigned to the intervention group and odd-numbered points were assigned to the control group. However, the patients and the recorders were blinded to intervention group assignments. A third researcher was aware of the final result after decoding. Different kinds of patches may apply to one patient.

FIR or placebo patches were applied to the patients for 24 h and then removed. Patients were informed and allowed to remove their patches at any time if severe skin itchiness or pain occurred after applying the patch.

The sample size was determined based on an effect size to detect significance of the intervention effect on the change in the primary outcome measures including V, P and T. If we permitted a 5% chance of type I error ($\alpha = 0.05$), with power of 80% and an 10% drop-out rate, assuming the difference before and after the intervention is at least half of the standard derivation of each parameter, then approximately 71 participants in each group would be required to have a sufficient sample size.

There were a total of 12 trigger points lost to follow-up in the all 201 trigger points, 3 in the intervention group while 9 in the control group. Therefore, data on 98 trigger points (60 patients) in the intervention group and 91 (57 patients) in the control group were included in the analysis (Fig. 2). Skin discomfort or sweat might have compromised the completion rate. The patches of 12 trigger points lost were accidentally removed by participants during sleep. No severe allergy was reported (Fig. 2).

2.5. Statistical analysis

Continuous data are expressed as mean ± standard deviation. The paired *t*-test was used to compare differences in parameters before and after the study. The Chi-square test was used for comparisons of categorical data. Differences in means of continuous variables were tested by the *t*-test. For the subgroup analyses, patients were further stratified by gender and by age. A *p* value less than 0.05 was considered to indicate statistical significance. All statistical analyses were performed with the statistical package SPSS for Windows (Version 19.0, SPSS, Chicago, Il).

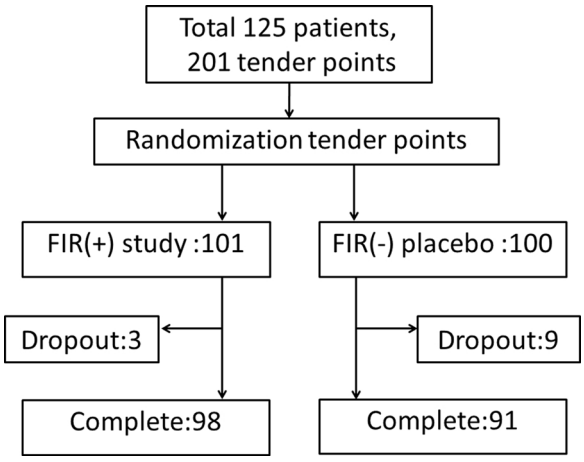

Fig. 2. The flow diagram of the study (n = 189 trigger points).

Table 1
The participants' sex and age distribution of each trigger points in the FIR and control groups (n = 201 trigger points before the study).

n (%)	All (n = 201)	FIR(+) (n = 101)	FIR(−) (n = 100)	*p*
Male	60(30.00%)	31(31.00%)	29 (29.00%)	0.360
Age (year)	37.11 ± 7.51	37.55 ± 7.96	36.67 ± 7.04	0.440
	Male n (age)	Female n (age)		*p*
Age (year)	60 (34.96 ± 7.54)	141(38.14 ± 7.30)		0.008*
< 35	40 (30.47 ± 2.30)	46(30.47 ± 3.23)		1
> =35	20 (43.95 ± 6.20)	95(41.79 ± 5.68)		0.146

FIR: far infrared; FIR+: intervention group; FIR−: control group.
* $p < 0.05$.

3. Results

As seen in Table 1, there were no significant differences in age or sex between the intervention and control groups before the intervention. Further analysis between different genders revealed that mean age of female participants was significantly older than that of male participants. The mean age of all participants is 37.11 ± 7.51, so we use the age of 35 as the cutoff age to reach a balanced number in younger and older group for comparison of the age-related difference.

As seen in Table 2, older age was highly correlated with higher P and T (but not with V) both before and after the study ($p < 0.001$). The V was not correlated with P or T, but P and T were highly correlated with each other before and after the study ($p < 0.001$).

We used the paired *t*-test to examine the parameters before and after the study. The V was significantly lower in both groups after the study (4.66–4.28 in the intervention group and in the control group, both $p < 0.001$), but P and T values only dropped significantly in the intervention group. (P decreased from 3.26 to 2.90 kg/cm^2, p = 0.014, and T decreased from 4.26 to 4.21 kg/cm^2, p = 0.019) (Table 3, Fig. 3)

When we stratified patients by gender, no difference of other parameters was found between male and female groups at baseline. Besides, we found no significant difference in pain reduction in between men and women. However, P and T values were significantly lower in the female group after treatment with FIR patches compared to the male group ($p < 0.05$). (Table 4)

The result of the subgroup analysis by age in each sex group is listed in Table 5. Only women aged over 35 with FIR patches had a significant fall in V, P and T. In addition, P and T were significantly higher in the younger males (than younger females) in the intervention group before the study, as well as in the older male group (than older female) (age > 35) in the intervention group after the study.

Table 2
The correlation analysis of age, pain intensity (V), pressure pain threshold (P) and maximal pain tolerance (T) (n = 189 trigger points after the study).

R (*p*)	V	P (kg/cm^2)	T(kg/cm^2)
Age(year)			
pre	0.103(0.178)	0.307(< 0.001)*	0.332(< 0.001)*
post	0.087(0.271)	0.337(< 0.001)*	0.373(< 0.001)*
V(kg/cm^2)			
pre	–	0.112(0.114)	0.061(0.389)
post	–	0.041(0.578)	0.058(0.428)
P(kg/cm^2)			
pre	–	–	0.909 (< 0.001)*
post	–	–	0.904 (< 0.001)*

Correlation coefficient (R); pre: before study; post: after study, V: visual analogue scale for pain, P: pressure pain threshold, T: maximal pain tolerance.
* $p < 0.05$.

Table 3
Changes in parameters after the study in the FIR and control groups (n = 189 trigger points which completed the study).

All	paired-*t* test (pre vs. post)			*t*-test (FIR+ vs. −)	
(n = 189)	pre	post	p	pre	post
V	4.80 ± 1.63	4.40 ± 1.74.	< 0.001*		
P(kg/cm^2)	3.15 ± 1.60	2.93 ± 1.53.	0.022*		
T(kg/cm^2)	4.44 ± 1.99	4.24 ± 2.11	0.073		
FIR+	n = 98				
V	4.66 ± 1.72	4.28 ± 1.82	< 0.001*		
P(kg/cm^2)	3.26 ± 1.67	2.90 ± 1.53	0.014*		
T(kg/cm^2)	4.63 ± 2.08	4.21 ± 2.16	0.019*		
FIR−	n = 91			*p*	*p*
V	4.78 ± 1.73	4.37 ± 1.80	< 0.001*	0.526	0.575
P(kg/cm^2)	2.93 ± 1.59	2.87 ± 1.60	0.585	0.307	0.989
T(kg/cm^2)	4.09 ± 1.98	4.22 ± 2.16	0.836	0.136	0.888

t-test: FIR vs. placebo, FIR: far infrared, FIR+: intervention group, FIR−: control group, V: visual analogue scale for pain, P: pressure pain threshold, T: maximal pain tolerance.
* $p < 0.05$.

4. Discussion

The mean age of women was greater than that of men in this study (male 34.96 ± 7.54 vs. female 38.14 ± 7.30), as well as the total number of female participants. (60 patches applied to men while 141 patches applied to women) However, when we stratified participants by age 35, there was no significant difference in age between younger men and women, neither in older men and women (Table 1).

Significant linear correlations were found between age and P as well as T, but not V. This finding might be due to the decreased skin sensitivity in older participants, as has been shown in an animal study.[22] It was also compatible with our finding that P and T were highly associated with each other (both P and T are indices of skin sensitivity), but not with V. In other words, older people may not suffer more pain, but may suffer poorer skin sensitivity than younger people.

We found that pain intensity in the trapezius region both decreased significantly to a similar extent in the intervention and in the control group. But contrary to our expectation, P and T decreased significantly only in the FIR group after intervention. According to the original theory of MPS, the threshold of P and T at active MTrPs should increase if pain is relieved with improved muscle blood circulation, because FIR activates the blood circulation to improve its tolerance of mechanical stimulus.[23,24] A possible explanation for this is that the duration of 24 h may be only enough for FIR to penetrate into the skin layer, but not into the muscle layer, thus only improving skin sensitivity but not muscle tolerance to pressure. The energy only penetrates into superficial skin but not the deeper muscle layer.[16,25]

The gender subgroup analysis revealed that all patients had pain relief, but only the female group had better response with improved skin sensitivity after treatment. This may be related to the effect of sex hormones such as estrogen, which contributes to thinner female skin thickness.[26] The age subgroup analysis revealed that FIR patches worked best in improving skin sensitivity among women aged over 35 years.

These findings are compatible with the following studies. Skin collagen decreased with age. The age related skin difference is shown in a large dermatology study which indicated in Chinese female, the sebum content and thickness are the highest in those aged below thirty-five.[27] Progressive simplification in the orientation of collagen could contribute to morphologic basis to age-associated biomechanical alterations in the skin.[28] Aging decreases dermal thickness and the spatial density of collagen bundles, thus increasing the textural heterogeneity of the dermis and hence making it easier for infrared radiation to penetrate the skin.[29]

We found that younger males had poorer skin sensitivity than

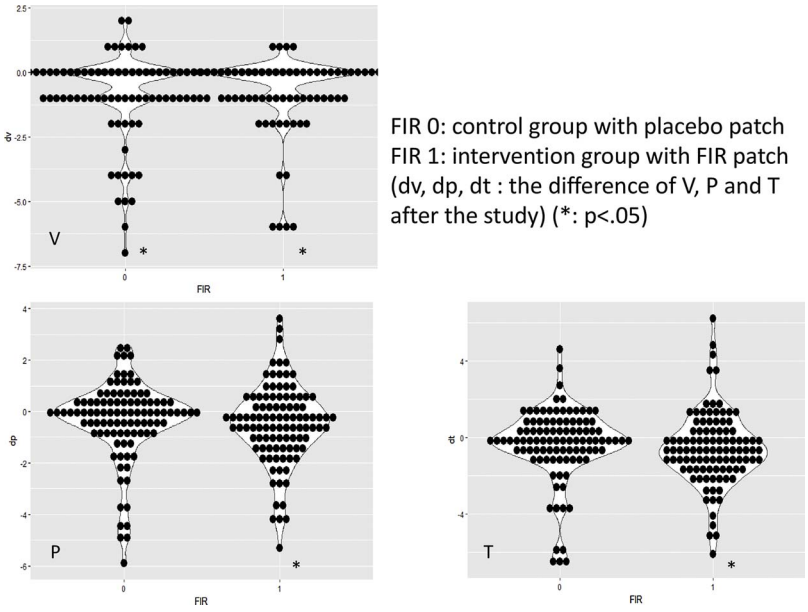

Fig. 3. Changes in baseline parameters after the study in the FIR and control groups.
Both groups had significant pain relief with decreased V, but only in the intervention group that pressure pain threshold (P) and maximal pain tolerance (T) decreased significantly after the study. (FIR: far infrared, FIR0: control group, FIR1: intervention group, *: $p < 0.05$)

younger females before the intervention, which probably because younger males have thicker skin. Male with higher collagen density in skin is associated with thicker dermal thickness. Males have thicker skin compared to age-matched females.[27] It may contribute to higher P and T in male than in female. The reason why FIR patch is most effective in improving skin sensitivity among women aged over 35, may be explained by that older age and female gender both contribute to thinner skin and allow more FIR to penetrate skin.

Our study showed better skin sensitivity in the female participants may be associated with improved skin blood circulation by FIR patches. Although the FIR patch resulted in a significant reduction in pain severity, there was no significant difference between the effect of the FIR patch and that of the placebo patch when applied for 24 h.

The strength of our study lies in its randomized, double-blind controlled design with a large sample size. In addition, we quantified the energy of the FIR patch using FTIR spectroscopy at the beginning of the study. The skin sensitivity is significantly improved in the intervention group, especially in the female participants. Skin sensitivity deteriorates with age but can be improved by FIR patch, which may be related to increased blood circulation in skin.[13,14] There are also evidences showing that FIR alone without heat modulates skin immune responses in vivo, indicating FIR might influence the skin and vessel by its thermal and non-thermal effect.[30]

The limitation of our study is that we did not test different temperatures as well as different durations of treatment for FIR patches. Second, the optimal duration of this patch applied to the skin to reach a deeper penetration is still unknown. Further studies with longer treatment durations are needed to evaluate whether FIR patch may be more effective at reducing the severity of pain than placebo. However, the dropout rate due to sweating or skin discomfort may also increase with longer study duration. (Our current dropout rate over 24 h is 5.9%). On the other hand, FIR devices with an external power supply (such as FIR lamp) with deeper penetration likely show a positive result and worth further investigation.

5. Conclusion

The FIR patch and placebo patch are equally effective at reducing pain severity when applied for 24 h in patients with MPS. The FIR patch resulted in better skin sensitivity mainly in women, especially in those aged over 35 years, probably due to thinner skin thickness in this subgroup. More clinical randomized trials are needed to develop optimized protocols and verify the efficacy of FIR patch in modulating pain in this condition.

Table 4
Changes in parameters after the study in the FIR and control groups, stratified by sex (n = 189 trigger points which completed the study).

	Male, paired-t (pre vs. post)			Female, paired-t (pre vs. post)			*t*-test (M/F)	
Sex(n)	M(n = 57) pre	post	*p*	F(n = 132)pre	post	*p*	pre *p*	Post *p*
V	4.40 ± 1.36	4.12 ± 1.51	0.003*	4.97 ± 1.71	4.52 ± 1.82	< 0.001*	0.066	0.151
P(kg/cm^2)	3.35 ± 1.44	3.10 ± 1.38	0.228	3.06 ± 1.67	2.86 ± 1.59	0.047	0.201	0.330
T(kg/cm^2)	4.85 ± 1.86	4.58 ± 1.96	0.299	4.27 ± 2.02	4.09 ± 2.16	0.141	0.065	0.143
FIR(+)	M (n = 32)		p	F (n = 66)				
V	4.25 ± 1.32	4.13 ± 1.41	0.211	4.94 ± 1.76	4.43 ± 1.94	< 0.001*	0.095	0.429
P(kg/cm^2)	3.48 ± 1.38	3.12 ± 1.46	0.198	3.20 ± 1.77	2.85 ± 1.53	0.035*	0.363	0.410
T(kg/cm^2)	5.07 ± 1.83	4.63 ± 2.05	0.255	4.50 ± 2.12	4.07 ± 2.16	0.032*	0.182	0.229
FIR(−)	M (n = 25)		p	F (n = 66)				
V	4.60 ± 1.41	4.12 ± 1.66	0.005*	5.00 ± 1.66	4.61 ± 1.70	0.007*	0.412	0.224
P(kg/cm^2)	3.19 ± 1.53	3.08 ± 1.29	0.731	2.92 ± 1.56	2.88 ± 1.65	0.672	0.426	0.589
T(kg/cm^2)	4.57 ± 1.91	4.51 ± 1.87	0.870	4.04 ± 1.90	4.10 ± 2.17	0.669	0.257	0.405

M for male, F for female, pre: before study, post: after study, *t*-test: male vs. female, FIR: far infrared, FIR+: intervention group, FIR−: control group, V: visual analogue scale for pain, P: pressure pain threshold, T: maximal pain tolerance.
* $p < 0.05$.

Table 5
Changes in parameters after the study in the FIR and control groups, stratified by sex and age of 35 (n = 189 trigger points which completed the study).

Sex (n)	male, paired-*t* test(pre vs. post)			female, paired *t*-test(pre vs. post)			*t*-test (male/female)	
	pre	post	*p*	pre	post	*p*	pre	post
FIR(+)							*p*	*p*
Age < 35	M(n = 20)	age 30.25 ± 2.29		F(n = 21)	age 30.59 ± 3.32			
V	4.30 ± 1.26	4.05 ± 1.13	0.187	4.41 ± 1.58	4.00 ± 1.83	.048*	0.812	0.918
P(kg/cm^2)	3.39 ± 1.64	2.75 ± 1.49	0.096	2.25 ± 0.81	2.34 ± 0.87	0.639	0.011*	0.346
T(kg/cm^2)	4.05 ± 1.13	3.99 ± 1.86	0.065	4.00 ± 1.83	3.07 ± 0.86	0.525	0.012*	0.066
Age > =35	M(n = 12)	age 43.58 ± 6.26		F(n = 45)	age 42.46 ± 6.36			
V	4.25 ± 1.54	4.17 ± 1.85	0.674	4.95 ± 1.43	4.57 ± 1.68	0.001*	0.153	0.486
P(kg/cm^2)	3.57 ± 0.89	3.58 ± 1.32	1.000	3.24 ± 1.89	2.62 ± 1.44	0.001*	0.559	0.048*
T(kg/cm^2)	5.48 ± 1.25	5.53 ± 2.12	0.954	4.45 ± 2.26	3.62 ± 1.76	< 0.001*	0.173	0.012*
FIR(−)								
Age < 35	M(n = 17)	age 30.72 ± 2.35		F(n = 24)	age 30.38 ± 3.23			
V	4.47 ± 1.13	3.94 ± 1.35	0.008*	5.00 ± 1.41	4.42 ± 1.46	0.061	0.280	0.315
P(kg/cm^2)	2.85 ± 1.58	2.71 ± 1.25	0.757	2.55 ± 1.70	2.76 ± 1.93	0.383	0.569	0.934
T(kg/cm^2)	4.18 ± 1.96	3.91 ± 1.70	0.557	3.49 ± 1.99	3.71 ± 2.09	0.408	0.274	0.756
Age > =35	M(n = 8)	age 44.57 ± 6.53		F(n = 42)	age 41.15 ± 4.93			
V	4.71 ± 2.06	4.57 ± 2.44	0.604	5.33 ± 1.76	4.92 ± 1.89	.041*	0.469	0.675
P(kg/cm^2)	3.86 ± 1.30	3.86 ± 1.13	1.000	2.67 ± 1.25	2.66 ± 1.50	0.871	0.061	0.051
T(kg/cm^2)	5.14 ± 1.53	5.56 ± 1.58	0.454	3.64 ± 1.48	3.63 ± 1.91	0.935	0.055	0.016*

M for male, F for female, pre: before study, post: after study, *t*-test: male vs. female; FIR: far infrared; FIR+: intervention group; FIR-: control group, V: visual analogue scale for pain, P: pressure pain threshold, T: maximal pain tolerance.
* $p < 0.05$.

Author disclosure statement

Institutional Review Board (IRB)/Ethics Committee approval was obtained before the trial began, and the study was conducted in full compliance with the Declaration of Helsinki.

Conflict of interest

None.

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