



ORIGINAL ARTICLE

Therapeutic Effects of Near-infrared Radiation on Chronic Neck Pain



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Purpose: We aimed to evaluate the therapeutic effects of near-infrared radiation on patients with chronic neck pain using various subjective and objective outcome measures.

Methods: Thirty participants with chronic neck pain between 20 years and 65 years of age were divided into two groups. Participants in Group A received near-infrared therapy every day for 1 week and no intervention in the following week. Group B participants received no intervention during the 1st week and near-infrared therapy every day in the following week. Quantitative measures of visual analog scale (VAS), pressure pain threshold (PPT), muscle stiffness, and skin-surface temperature were obtained using specific equipment.

Results: Both groups showed significant increases in VAS scores after receiving near-infrared therapy. In most of the sampled muscles, PPT values also increased after receiving near-infrared therapy in both groups. All other outcome measures collected prior to and after therapy displayed nonsignificant differences.

Conclusion: Results from this pilot study indicate that near-infrared therapy reduces pain and partially increases PPT. Further investigation of the long-term effects of near-infrared therapy on a larger population is warranted.

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1. Introduction

Neck pain is a common complaint in clinical practice and a major cause of activity limitations, disability, and loss of productivity. The prevalence of neck pain with or without upper limb pain ranges from 9% to 18% in the general population, and one in three people can recall at least one incidence of neck pain within their lifetime.^{1,2} A wide range of interventions is used to treat neck pain including drugs, physical therapy,³ acupuncture or dry needling,^{4,5} local injection,⁶ botulinum toxin,⁷ and educational programs.⁸ However, there remains a lack of consensus on the optimal treatment for chronic neck pain.

Although previous studies on the subject are limited, investigators have shown that electromagnetic waves of near- and far-infrared spectra produce thermal and nonthermal effects, including increased microvascular dilatation and elevated regional tissue temperatures.^{9,10} Infrared radiation, a form of radiant energy, is emitted from any substance with a temperature higher than

absolute zero. Infrared is the portion of the electromagnetic spectrum adjacent to the long-wavelength low-frequency end of the visible spectrum. Infrared produces heat by inducing molecular vibration. Luminous infrared heat lamps emit radiation in the near-infrared spectrum (770–1500 nm wavelength), and nonluminous infrared heat lamps emit radiation in the far-infrared spectrum (1500–12,500 nm wavelength).¹¹

Previous studies have described several positive clinical effects of infrared radiation, including relief of arthritic knee pain,¹² improved wound healing,^{13–15} reduced chronic low back pain,¹⁶ and increased endorphin levels.¹⁷ However, to our knowledge, few studies have evaluated the therapeutic effects of near-infrared radiation on patients with chronic neck pain using subjective and objective outcome measures. Therefore, the aim of this study was to administer near-infrared radiation to patients with chronic neck pain and to evaluate its clinical effects.

2. Methods

2.1. Participants

Thirty community-living participants (age range, 20–65 years) with chronic neck pain completed the study. The participants were randomly divided into two groups. Fifteen participants were

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included in Group A (8 men and 7 women; mean age: 34.5 years), and 15 participants were included in Group B (9 men and 6 women; mean age: 31.5 years). Participants were excluded if they had impaired sensation, acute trauma, rheumatological disorders including ankylosing spondylitis, rheumatoid arthritis or systemic lupus erythematosus, cervical spondylosis, cervical radiculopathy or myelopathy, fibromyalgia, history of psychological diseases, or were pregnant or planned pregnancy. This study was conducted at Taipei Medical University Hospital and approved by the Institutional Review Board. The potential risks and benefits of participation were explained to each participant. All participants reviewed an informed consent document and provided written consent prior to participating in the study.

2.2. Study design

This study was designed as a randomized crossover 2-week trial to determine the effects of near-infrared radiation on participants with chronic neck pain. Group A received near-infrared radiation every day for 1 week and no intervention in the following week. Group B received no intervention during the first week and near-infrared radiation in the following week.

2.3. Intervention

A 650-W infrared halogen lamp (InfraCare HP 3643; Philips Electronics Industries Ltd, Taipei, Taiwan) was used to administer infrared radiation to all participants. The lamp covered 60 cm × 40 cm area over the upper back and neck regions.

2.4. Outcome measures

Outcome measures of participants in Group A were assessed prior to therapy, 15 minutes after therapy, after 1 week of treatment, and 1 week after cessation of therapy. Outcome measures of participants in Group B were assessed at baseline, prior to therapy, 15 minutes after therapy, and after 1 week of treatment (Figure 1).

2.4.1. Visual analog scale measurements

Participants were asked to mark a 10-cm horizontal line to describe their perception of pain from none to mild, moderate, and severity.

2.4.2. Measurement of muscle stiffness (muscle tone and compliance)

The Myotonometer (Neurogenic Technologies Inc., Missoula, Montana, USA), a patented computerized electronic tissue compliant meter-type device, and a pressure meter were used to evaluate muscle stiffness. In this study, each participant was required to sit on a chair with their trunk upright, their shoulders in a horizontal position on both sides, and their palms placed on their thighs. Muscle stiffness was measured repeatedly on both sides of the trapezius and splenius capitis muscles. The sites for measurement (in the center of the muscle belly) were identified using manual palpation and marked using a pen. Measurements were taken at eight-force increments (0.25 kg, 0.50 kg, 0.75 kg, 1.0 kg, 1.25 kg, 1.50 kg, 1.75 kg, and 2.00 kg). Force–displacement curves were created using computational software and the areas under the curves (AUCs) were calculated from the obtained data. These data provide a reliable measure of muscle stiffness as described previously.^{18,19} In this study, myotonometer measurements of the trapezius and splenius capitis muscles were acquired at rest. Measurement periods were lasted for 6 seconds, with an interval of 2 seconds, and the three points for measurement were the 1st second, 3rd second, and 5th second. Each assessment was repeated after a 2-minute interval.

2.4.3. Measurement of pressure pain threshold

The participants were seated comfortably on a chair with a low support for the back and arms. The pressure pain threshold (PPT) recording points were selected and marked using a pen. The PPT values of the trapezius and splenius capitis muscles were measured three times (at 30-second intervals) bilaterally using an algometer (FORCE DIAL; Wagner Instruments, Greenwich, Connecticut, USA). Pressure was applied perpendicularly to the skin at the marked points. Measurements were collected with continuous application of increasing pressure, at a uniform rate of 1 kg/second, until the patient experienced pain and requested pressure cessation. The PPT was defined as the lowest pressure required for a participant to feel pain.

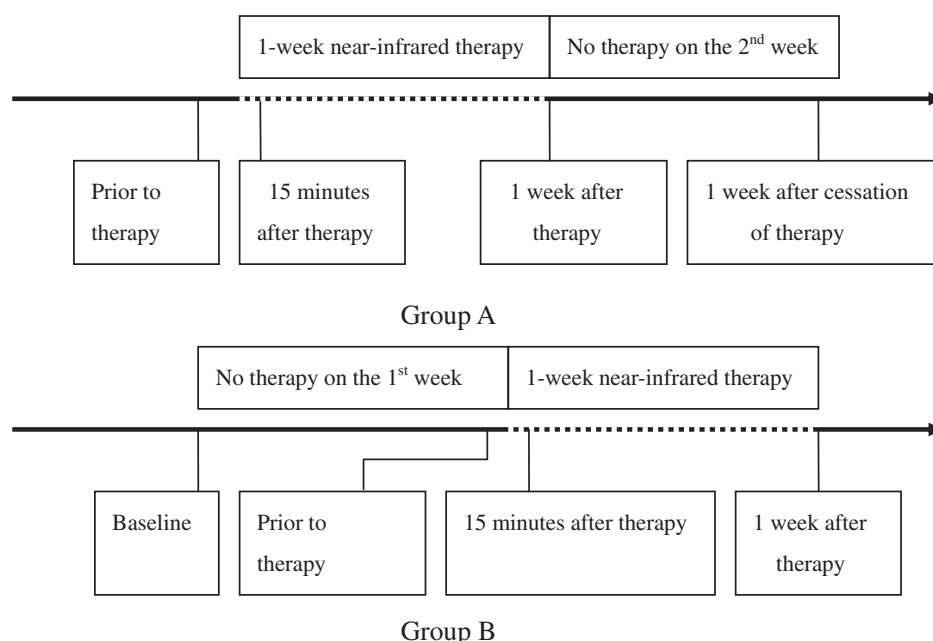


Figure 1 Study procedures for Groups A and B.

Table 1 VAS scores, PPT values, AUC values, and skin-surface temperatures in Group A ($n = 15$)

		A1	A2	A3	A4
VAS**		5.60 (1.59)	4.4 (1.50)	4.01 (1.87)	5.13 (1.41)
PPT (kg/cm ²)	Left trapezius muscle	2.39 (0.51)	2.66 (0.46)	2.58 (0.53)	2.70 (0.63)
	Right trapezius muscle	2.34 (0.56)	2.66 (0.43)	2.62 (0.49)	2.60 (0.60)
	Left splenius capitis muscle	1.84 (0.33)	2.05 (0.39)	1.98 (0.34)	2.11 (0.35)
	Right splenius capitis muscle	1.70 (0.32)	1.94 (0.33)	1.99 (0.43)	2.03 (0.38)
AUC (kg/mm)	Left trapezius muscle	17.14 (2.70)	16.57 (1.88)	17.15 (2.40)	16.90 (3.12)
	Right trapezius muscle	16.82 (2.70)	16.85 (2.59)	16.68 (2.83)	16.44 (3.19)
	Left splenius capitis muscle	17.39 (2.90)	17.10 (2.06)	18.99 (2.11)	18.59 (1.99)
	Right splenius capitis muscle	16.72 (2.45)	17.28 (1.72)	18.25 (2.01)	17.49 (2.89)
Skin temperature (°C)	Neck	32.37 (3.08)	32.64 (3.64)	31.42 (2.88)	31.96 (2.11)
	Upper back	32.63 (2.79)	32.58 (3.96)	31.28 (4.28)	31.60 (3.47)

* $p < 0.05$ and ** $p < 0.01$, differences in outcome variables compared with outcome variables prior to therapy.

A1 = prior to therapy; A2 = 15 minutes after therapy; A3 = after 1 week of therapy; A4 = 1 week after cessation of therapy.

VAS = visual analog scale; PPT = pressure pain threshold; AUC = area under the curve.

Each muscle test was separated by a 2-minute interval. The same examiner collected all measurements for all participants. Previous studies have shown that the reliability and test–retest repeatability of pressure pain for each point in all sessions are high.^{20,21}

2.4.4. Measurement of skin-surface temperature

A digital infrared thermal image system (SPECTRUM9000MB-500 System, UIS Co, Taipei, Taiwan) was used to measure skin-surface temperature. The mean skin-surface temperature in the neck and upper back was assessed prior to and after therapy in both groups and the values were compared. Previous studies have shown that measurement of skin-surface temperature can provide an objective tool during the diagnosis and follow-up of patients with myofascial pain, and is associated with high accuracy and repeatability in pain measurements.^{22,23}

2.5. Statistical analysis

Repeated-measures analysis of variance (ANOVA) was used to evaluate the differences between measurement parameters. A p value < 0.05 was considered statistically significant. Following a significant ANOVA test result, Bonferroni *post hoc* analysis was conducted to further evaluate the differences between parameters. Statistical analyses were performed using Statistical Package for Social Science software version 18.0 (SPSS Inc., Chicago, Illinois, USA).

3. Results

3.1. Visual analog scale measurements

In Group A, the mean visual analog scale (VAS) score was decreased from 5.60 (prior to therapy) to 4.4 (15 minutes after therapy). After

1 week of therapy, the mean VAS score further reduced to 4.01 ($p < 0.001$; Table 1).

In Group B, the mean VAS score decreased from 5.40 (prior to therapy) to 4.37 (15 minutes after therapy; $p < 0.01$). After 1 week of therapy, the mean VAS score further was reduced to 4.00 ($p < 0.05$; Table 2).

3.2. Measurement of muscle stiffness (muscle tone and compliance)

In both groups, the AUC values of the bilateral trapezius and splenius capitis muscles collected prior to and after therapy displayed nonsignificant differences (Tables 1 and 2).

3.3. PTT measurements

In Group A, in the right splenius capitis muscle, the mean PPT value increased from 1.70 (prior to therapy) to 1.94 (15 minutes after therapy; $p < 0.01$), and then to 1.99 (after 1 week of therapy; $p < 0.05$). In the bilateral trapezius and left splenius capitis muscles, mean PPT values collected prior to and after therapy showed an increasing trend (Table 1).

In Group B, in the left trapezius muscle, the mean PPT value increased from 2.30 (prior to therapy) to 2.57 (15 minutes after therapy; $p < 0.05$; Table 2), and then to 2.74 (after 1 week of therapy; $p < 0.05$). In the right trapezius muscle, the mean PPT value increased from 2.22 (prior to therapy) to 2.54 (15 minutes after therapy; $p < 0.01$), and then to 2.79 (after 1 week of therapy; $p < 0.01$; Table 2). In the right splenius capitis muscle, the mean PPT value increased from 1.76 (prior to therapy) to 1.98 (15 minutes after therapy, $p < 0.05$), and then to 2.15 (after 1 week of therapy; $p < 0.01$; Table 2).

Table 2 VAS scores, PPT values, AUC values, and skin-surface temperatures in Group B ($n = 15$)

		B1	B2	B3	B4
VAS*		5.40 (1.72)	5.54 (1.77)	4.37 (1.56)	4.00 (1.85)
PPT (kg/cm ²)	Left trapezius muscle	2.42 (0.42)	2.30 (0.18)	2.57 (0.34)*	2.74 (0.56)
	Right trapezius muscle	2.41 (0.45)	2.22 (0.34)	2.54 (0.76)**	2.79 (0.47)**
	Left splenius capitis muscle	1.96 (0.44)	1.83 (0.38)	1.96 (0.38)	2.21 (0.44)
	Right splenius capitis muscle	1.89 (0.29)	1.76 (0.40)*	1.98 (0.44)*	2.15 (0.57)**
AUC (kg/mm)	Left trapezius muscle	16.77 (2.87)	16.47 (2.40)	17.13 (2.10)	16.86 (2.73)
	Right trapezius muscle	16.52 (1.86)	16.66 (1.44)	16.67 (1.62)	17.48 (2.54)
	Left splenius capitis muscle	17.25 (2.17)	17.04 (1.82)	17.18 (1.85)	17.56 (2.89)
	Right splenius capitis muscle	17.15 (2.26)	17.22 (3.01)	17.04 (2.60)	16.91 (2.62)
Skin temperature (°C)	Neck	32.94 (2.76)	32.78 (4.28)	32.97 (4.71)	32.07 (3.24)
	Upper back	32.86 (1.00)	32.57 (4.58)	33.04 (4.90)	32.27 (3.14)

* $p < 0.05$ and ** $p < 0.01$, differences in outcome variables compared with outcome variables prior to therapy.

Bonferroni *post hoc* test: B1 = baseline; B2 = prior to therapy; B3 = 15 minutes after therapy; B4 = after 1 week of therapy.

AUC = area under the curve; PPT = pressure pain threshold; VAS = visual analog scale.

3.4. Measurement of skin-surface temperature

In both groups, skin-surface temperatures collected prior to and after therapy showed nonsignificant differences (Tables 1 and 2).

4. Discussion

The results from this crossover study indicate that near-infrared radiation reduced pain significantly and partially modulate mechanical pain perception in patients with chronic neck pain. Our results support a previous report,¹⁶ which showed that infrared radiation effectively reduces chronic lower back pain. Nuhr et al²⁴ previously identified that local heat therapy exerts pain-relieving effects and can increase the elasticity of connective tissues.

Although the exact mechanisms underlying the therapeutic effects of near-infrared radiation on PTT have yet to be fully elucidated, our results of trends toward increasing PPT values following the application of near-infrared radiation are encouraging. Near-infrared radiation might exert direct heating effects on free nerve endings or nerve trunks that supply an affected area through various mechanisms, including effects on neuronal membrane potentials,²⁵ to reduce pain and increase the pain threshold.

Myotonometer force–displacement curves represent the amount of tissue displacement caused by a given unit of force applied perpendicular to a muscle. Increasing AUC values reflect decreasing muscle stiffness. In previous investigations, thermal stimuli to the surface of the body relieved muscle stiffness by inhibiting sympathetic activity and stimulating parasympathetic activity. Reduced muscle tension might relieve pain and fatigue.²⁶ However, in our study, the AUC values for the bilateral trapezius and splenius capitis muscles collected prior to and after therapy showed nonsignificant differences. It is possible that near-infrared radiation was unable to reduce muscle stiffness, or that the duration of the intervention was too short to induce significant effects.

In this study, skin temperatures of the neck and upper back measured prior to and after therapy showed nonsignificant differences. The reason for this finding remains unclear. Cooling of the skin might occur secondarily to sympathetic overactivity because of nociceptor and mechanoreceptor stimulation, leading to a reflex neuropathic state. Increases in sympathetic efferent activity can result in painful responses to afferent stimuli.^{27,28} Elevated skin temperatures might reflect reduced sympathetic activity and increased regional microcirculation. However, the correlation between skin temperature and pain levels requires further investigation.

Because infrared radiation warms up the tissues, it is judicious to avoid its use in patients with malignant hyperthermia and in patients with scleroderma, because some forms of the condition can deteriorate in sunlight, which has a wavelength close to that of infrared radiation. In addition, repeated and prolonged exposure of the skin to heat can result in erythema ab igne, a skin condition characterized by reticular pigmentation and telangiectasia, although this effect has yet to be reported following the administration of infrared radiation.²⁹ In our study, we observed no adverse effects following the application of near-infrared radiation.

Biophysical methods that promote health show an increased popularity, and near-infrared radiation could provide a valuable alternative intervention for some types of chronic pain. However, further prospective clinical trials and evidence-based experimental studies are needed to confirm its potential use as a complementary and alternative method for relieving symptoms of neck pain. In the future, near-infrared radiation could potentially be used to reduce patients' dependence on nonsteroidal anti-inflammatory drugs and other pain relief medication.

This study has several limitations. One limitation was the lack of experimental blinding of the participants; they were aware of having received infrared radiation. However, the use of a different trainer and assessor allowed for experimental blinding of the assessor. Another limitation of this study was its limited sample size. Further clinical trials are needed on a larger population to provide more comprehensive results. One further limitation was the short duration of therapeutic application; therefore, the long-term effects of near-infrared radiation could not be determined. The PPT values can also potentially be influenced by psychological factors such as depression or anxiety. Future studies should include the assessment of these factors.

In conclusion, results from this pilot study indicate that patients with chronic neck pain show improved pain scales and partially increased PPT in response to near-infrared radiation. The long-term effects of near-infrared radiation on a larger population warrant further investigation.

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