Correlation Between Skin Temperature Over Myofascial Trigger Points in the Upper Trapezius Muscle and Range of Motion, Electromyographic Activity, and Pain in Chronic Neck Pain Patients

Carlos Eduardo Girasol, PT, Almir Vieira Dibai-Filho, PT, PhD, Alessandra Kelly de Oliveira, PT, and Rinaldo Roberto de Jesus Guirro, PT, PhD

Abstract

Objective: The purpose of this study was to assess the correlation between skin temperature over a myofascial trigger point in the upper trapezius muscle and range of motion of the cervical spine, electromyographic activity, and pain in patients with chronic neck pain.

Methods: This is a single-blind cross-sectional study. Forty participants of both sexes, aged 18 to 45 years, with chronic neck pain and myofascial trigger points in the upper trapezius muscle were included in the study. The participants were assessed using the Numeric Rating Scale, the Neck Disability Index, infrared thermography, algometry, fleximetry, and electromyographic activity.

Results: A positive association was observed between skin temperature to the right with the range of motion of cervical flexion ($r = 0.322$, $P = .043$), the median frequency of isometrics to the right ($r = 0.341$, $P = .032$), and the median frequency of rest to the left ($r_s = 0.427$, $P = .006$); as were a negative association between skin temperature to the right and the root mean square of rest to the right ($r_s = -0.447$, $P = .004$), and a positive association of skin temperature to the left with the median frequency of isometrics to the right ($r = 0.365$, $P = .020$), and the median frequency of rest to the left ($r_s = 0.573$, $P < .001$).

Conclusion: Patients with chronic neck pain who had reduction of skin temperature over myofascial trigger points in the upper trapezius muscle had reduced cervical range of motion for flexion, reduced median frequency at rest and during isometric contraction, and increased root mean square at rest. (J Manipulative Physiol Ther 2018;41:350-357)

Key Indexing Terms: *Physical Therapy Modalities; Myofascial Pain Syndromes; Muscle, Skeletal; Thermography*

Introduction

Neck pain is a prevalent musculoskeletal dysfunction that is related to new lifestyles and work activities.[1,2] Among the various anatomic structures involved in the pathologic process of neck pain, the myofascial component stands out,[1] especially the trapezius muscle.[3] Studies show that individuals with chronic pain have metabolic,[4] vascular,[5] and electromyographic[3] alterations in this muscle. A common clinical sign in the trapezius muscle of individuals with neck pain is the presence of myofascial trigger points.[6]

Myofascial trigger points, which are defined as palpable nodules located in the taut band of a skeletal muscle, are related to sensory, motor, and autonomic changes. They also produce local and referred pain and may be active or latent.[2,7] It has been proposed that the etiologic process of myofascial trigger points is related to direct muscle trauma or overuse.[2]

Several studies have used criteria[8] based on muscle palpation for diagnosing myofascial trigger points. However, other methods[9] highlight that palpation requires a combination of skill, training, and critical clinical practice. Other instruments such as ultrasound,[10] sonoelastography,[11] and electromyography also have applicability in assessing patients with myofascial trigger points.[12]

Postgraduate Program in Rehabilitation and Functional Performance, Department of Biomechanics, Medicine, and Rehabilitation of the Locomotor Apparatus, Medical School of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil.

Corresponding author: Rinaldo Roberto de Jesus Guirro, PT, PhD, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Avenida dos Bandeirantes, 3900, Prédio da Fisioterapia e Terapia Ocupacional, Monte Alegre, Ribeirão Preto, SP, Brazil, CEP 14049-900. Tel.: +55 1633154584. (e-mail: *rguirro@fmrp.usp.br*).

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In this context and considering the autonomic and metabolic repercussions caused by the presence of myofascial trigger points,[2] we can also add infrared thermography as a possible method in the evaluation of individuals with myofascial pain.[13,14] It is a noninvasive, painless method that does not require contact with the region being evaluated. It is based on the emission of infrared radiation by bodies with a temperature above absolute zero, providing an image of the distribution of the body's skin temperature, which is conditioned by microcirculatory activities.[15]

However, the possible correlation between skin temperature and the other clinical variables used in evaluating the trigger point has not yet been fully understood by the scientific literature. There is a need to establish the possible association between skin temperature and common medical complaints in patients with myofascial trigger points with chronic neck pain, such as pain, limitation in the range of cervical motion, and muscle tension. Given this context, the aim of this study was to correlate skin temperature at the myofascial trigger point in the upper trapezius muscle with the range of motion of the cervical spine, electromyographic activity, and pain in patients with chronic neck pain.

Methods

Ethics

The study was approved by the Research Ethics Committee of the Clinics Hospital of the Medical School of Ribeirão Preto of the University of São Paulo, under opinion number 030643/2013. The recruitment of the participants took place in the city of Ribeirão Preto (São Paulo, Brazil), using posters, radio, and the internet. The invitation to participate was done verbally. All participants consented to partake.

Study Design

This is a single-blind cross-sectional study in which 1 physiotherapist (A.V.D.-F.) was responsible for recruiting, diagnosing, and assessing pain, electromyographic activity, and the cervical range of motion. A second physiotherapist (A.K.d.O.) was responsible for thermal evaluation, and a third (C.E.G.) conducted the processing and analysis of the data collected.

Sample

The processing of the sample size calculation was performed using Ene software, version 3.0 (Autonomous University of Barcelona, Barcelona, Spain). The sample size was calculated based on the study carried out by Haddad et al,[14] which found a correlation between skin temperature at the myofascial trigger points and pain. The calculation was based on the detection of a moderate association (r = 0.50) between the variables. Thus, a number of 34 participants was estimated to reach a statistical power of 90% and an α of 0.05. Anticipating a possible sample loss, 40 participants were recruited for this study.

Participants were both sexes between the ages of 18 to 45 years, and they had chronic neck pain (>90 days), which was identified in accordance with the following criteria: score on the Neck Disability Index (NDI) $\geq$5 points and score on the Numeric Rating Scale (NRS) $\geq$3 at rest or during active movement of the cervical. Furthermore, the participants had an active and central myofascial trigger point in the upper trapezius muscle, diagnosed according to the criteria established by Simons et al[8] and Gerwin et al[16]: the presence of a taut band in the skeletal muscle, the presence of a hypersensitive point within the taut band, local contraction in response to the palpation of the taut band, and reproduction of the referred pain due to compression of up to 2.5 kg/cm^2 on the trigger point.[17] It should be pointed out that these diagnostic criteria of the myofascial trigger point have acceptable levels of reliability, with κ values ranging between 0.36 and 0.88[16] and having been carried out by a physiotherapist with 8 years of experience with myofascial pain.

Excluded from the study were participants who had a history of trauma in the neck; undergone head, face, or neck surgery; had a cervical hernia or degenerative diseases of the spine; had been subjected to physical therapy treatment in the previous 3 months; had used an analgesic, anti-inflammatory, or muscle relaxant in the previous week; had systemic diseases; had a medical diagnosis of fibromyalgia; or a had body mass index (BMI) greater than 28 kg/m^2, according to Albuquerque-Sendín et al.[18] Also excluded from the study were participants with symptoms of depression, as evaluated by the Beck Depression Inventory.[18,19]

Anamnesis and Physical Examination

The following data were collected by the evaluator: personal data, weight (kg), height (m), BMI (kg/m^2), previous diseases, use of medication, and history of surgery or physical therapy. Furthermore, as described in the exclusion criteria, the Beck Depression Inventory (Gorenstein and Andrade[19]) was used to identify symptoms of depression in the participants (score >9 points).

Neck Disability Index

The NDI is an instrument adapted and validated for the Brazilian population[20]; it has 10 questions that investigate disability and neck pain. For each question, it is possible to mark 1 of 6 answers, corresponding to scores of 0 to 5. Therefore, the score for classification of disability due to pain varies from 0 to 50 points, as follows: 0 to 4 points, no disability; 5 to 14 points, mild disability; 15 to 24 points, moderate disability; 25 to 34 points, severe disability; and 35 to 50 points, complete disability.[21]

Numeric Rating Scale

The NRS is a simple and easily measured scale consisting of a sequence of numbers, 0 to 10, in which 0 represents “no pain” and 10 represents “the worst pain imaginable.” This is how the participants graded their neck pain, based on these parameters.[22] Pain intensity was assessed with the individual at rest and after active motion of the cervical spine.

Infrared Thermography

To carry out infrared thermography, the participants remained in a room with a temperature around 23°C for a period of 15 minutes,[23] without the presence of electrical equipment that generated heat and with no direct incidence of air or sunlight. The examination room was illuminated by fluorescent lamps. Two hours before the collection, the participants were instructed to avoid hot baths or showers; topical agents, creams, or powders; strenuous exercise; and stimulants such as caffeine, nicotine, or chocolate. During the collection, the participants remained seated on a bench with their trunks upright and their hands on their thighs. The region of muscles to be evaluated was free of clothing and personal items such as earrings, necklaces, or similar objects; hair was tied back when necessary.[24]

A thermal camera, model T300 (FLIR Systems, Wilsonville, Oregon) was used, which has a precision accuracy of up to 0.05°C, establishing an emissivity of 0.98. The instrument was stabilized for 10 minutes before the examination. Three infrared images were captured in sequence at a distance of 100 cm from the participant, with the muscles to be evaluated in a normal perpendicular position. QuickReport software, version 1.2 (FLIR Systems), was used to determine the temperature value at the myofascial trigger point.

For the analysis of the infrared image, as a way to ensure the analysis of the skin temperature exactly at the myofascial trigger points, 4 polystyrene markers were used, 8 mm in diameter, positioned equidistant at a distance of 25 mm from the center of the myofascial trigger point. This method of assessing the infrared image was supported in a recent study by our research group, in which excellent intrarater and interrater reliability was identified for an exact analysis of the infrared image at the myofascial trigger point, with values of 0.95 and 0.90, respectively, for the intraclass correlation coefficient (ICC).[25] Furthermore, the compressive force used for the diagnosis of myofascial trigger points does not affect the skin temperature because the procedure is carried out 15 minutes after the application of the force.[23]

Algometry

A PTR-300 algometer (Instrutherm, São Paulo, Brazil) was used to measure the pressure pain threshold. The participants sat upright in a chair, with the back fully supported, their feet flat on the floor, and their hands resting on their legs. A trained examiner positioned the tip (1 cm^2) of the algometer perpendicular to the fibers of the upper trapezius muscle, bilaterally, exactly on the myofascial trigger points, and exercised gradual compression at a rate of about 0.5 $kg/cm^2/s$, controlled by audible feedback from a digital metronome.[26] These points were pressed up to the intensity at which the participant reported pain, and this amount of pressure was recorded in kg/cm^2. The measurement of the pressure pain threshold was performed 3 times for each muscle, and the average value was calculated. This evaluation produced acceptable ICC values of 0.88 to 0.90 and 0.74 to 0.89 for intrarater and interrater reliability, respectively.[27]

Fleximetry

An FL6010 fleximeter (Sanny, São Bernardo do Campo, São Paulo, Brazil) was used to measure the amplitude of the following movements of the cervical spine: flexion, extension, lateral inclination to the right and left, and rotation to the right and left. To assess the range of movement of cervical flexion and extension, the participant remained seated while the fleximeter was positioned next to the head over the ear. For lateral inclination, the fleximeter was placed in the external occipital protuberance region, with the participant sitting. For rotation, the participant got in a supine position with the head above the examination table’s plane, with shoulders touching the edge of the table, and the fleximeter was positioned at the center point of the head.[28] Florêncio et al[29] established acceptable levels of reliability for these assessments, with intrarater and interrater ICC values of 0.69 to 0.80 and 0.66 to 0.88, respectively.

Electromyographic Activity

The electromyographic examination was performed by using the EMG 1000 electromyograph (Lynx, São Paulo, Brazil) with a resolution of 16 bits and a sampling frequency of 2000 Hz per channel. The electromyographic signals collected were sampled synchronously and stored for later viewing and processing. AqDados software, version 7.2 (Lynx), was used for acquiring and storing the data files of the digitized signals, which allows acquisition of up to 32 analog channels with sampling frequency and a programmable test duration, allowing the processing of the data after acquisition and making it compatible with universal formats.

Simple active differential electrodes were used for capturing the action potential of the upper trapezius muscle, if their placement was in accordance with the Surface Electromyography for the Non-Invasive Assessment of Muscles guidelines, which means the electrode is placed between the spinous process of the C7 vertebra and the acromion, bilaterally. The active surface electrodes (Lynx) were composed of 2 parallel bars of pure silver, each 10 mm long by 1 mm wide and separated from each other by 10 mm. They had a preamplifier circuit with a gain of 20 times (±1%), a common mode rejection ratio >100 dB, and a signal noise ratio <3 μV root mean square (RMS) with a subsequent amplification of 50 times on the acquisition board, which amounts to an amplification of the electromyographic signal 1000 times. A ground electrode consisting of a metal plate was fastened to the participant's sternum and used to eliminate any outside interferences. A high-pass filter of 20 Hz was used along with a low-pass filter of 1000 Hz.

During the electromyography, the participants were placed in a sitting position with their trunks upright and their backs fully supported, their feet parallel and supported on a rubber mat, and their hands on their thighs. The electromyographic collection of the upper trapezius muscle was done in 2 distinct phases: rest and isometrics, both for 4 seconds. In each situation, 3 records of the electromyographic signal were carried out at intervals of 2 minutes (only for isometric contraction) to avoid muscle fatigue. For the isometric analyses, the examiner would give a clear, loud, and steady verbal stimulus, with the patient positioned on a support specially designed for this activity, which restricted the elevation of the shoulders.

A collection of maximal voluntary isometric contraction values was done prior to the initial assessment, which was used for normalization of the RMS collected. The analysis of the electromyographic signal took place in the domain of time and frequency, and the RMS (%) and the median frequency (Hz) were used as analytical parameters of muscle activity. The processing was done by routines implemented in the software Matlab, version 6.5 (Natick, Massachusetts). Ives and Doherty[30] established good levels of reliability for electromyographic evaluation of the upper trapezius muscle, with intrarater and interrater ICC values of 0.77 and 0.79, respectively.

Statistical Analysis

Initially, the distribution of the data from the Kolmogorov-Smirnov test was analyzed. The Pearson correlation coefficient (r) was applied to check the association between the skin temperatures and the following variables: the pressure pain threshold to the right and left; ranges of cervical motion for flexion, extension, inclinations to the right and left, and rotations to the right and left; the median frequency of isometrics and of rest to the right; and the RMS of isometrics to the left. The Spearman correlation coefficient (r_s) was used to check the association between skin temperature and the following variables: the NRS at rest and during active movement of the cervical spine; the NDI; the RMS of isometrics and at rest to the right; the RMS at rest to the left; and the median frequency of isometrics and at rest to the left. The classification established by Munro[31] was used for interpreting the magnitude of the correlations: 0.26 to 0.49, weak; 0.50 to 0.69, moderate; 0.70 to 0.89, high; and 0.90 to 1.00, very high. Data processing was performed using the software Statistical Package for the Social Sciences, version 17.0 (SPSS Inc, Chicago, Illinois).

Results

Fifty-seven participants of both sexes were recruited for the study. Seventeen participants were excluded for the following reasons: 5 had a score <5 on NDI, 5 had scores <3 on the NRS, 4 had latent myofascial trigger points, 2 had unilateral myofascial trigger points, and 1 did not have any myofascial trigger points.

Therefore, 40 participants were included in the study, of which 38 were women and 35 were right-handed. The mean age was 24.31 years (standard deviation [SD] = 4.16), the mean BMI was 22.90 (SD = 2.69), the mean chronic cervical pain duration was 55.09 months (SD = 36.80), and the mean score on the Beck Depression Inventory was 4.92 points (SD = 2.50). The values of central tendency and dispersion of the study's variables are described in Table 1.

With respect to the correlations between the variables, the following significant results were observed: a positive association between skin temperature to the right and the range of cervical flexion ($r = 0.322$, $P = .043$), the median frequency of isometrics to the right ($r = 0.341$, $P = .032$), and the median frequency of rest to the left ($r_s = 0.427$, $P = .006$); a negative association between skin temperature to the right and the RMS of rest to the right ($r_s = -0.447$, $P = .004$); and a positive association between skin temperature to the left and the median frequency of isometrics to the right ($r = 0.365$, $P = .020$) and the median frequency of rest to the left ($r_s = 0.573$, $P < .001$). Other correlations are presented in Table 2.

Discussion

Significant correlations were observed in this study between skin temperature and the electromyographic activity analyzed in the domain of time and frequency: the RMS at rest and median frequency at rest and isometrics. The scientific literature does not show studies evaluating individuals with pain by means of infrared thermal imaging and electromyography. However, associations between skin temperature and other clinical variables have been made. Dibai-Filho et al[32] investigated individuals with temporomandibular disorder, and no association was found between the skin temperature of the masticatory muscles and pain intensity. On the other hand, Haddad et al[14] observed a positive correlation between the pressure pain threshold in the

Table 1. *Description of the Mean Values, SD, Median, and First and Third Quartiles of the Study's Variables (n = 40)*

Outcomes	Mean	SD	Median	1st Quartile	3rd Quartile
Left SkT (°C)	33.22	1.06	33.33	32.85	33.78
Right SkT (°C)	33.23	1.01	33.23	32.49	33.92
NRS at rest (score)	3.50	1.93	3.00	2.00	5.00
NRS at motion (score)	5.42	1.95	5.00	4.00	7.00
NDI (score)	11.57	3.88	11.00	9.00	14.00
PPT to the right (kg/cm^2)	1.52	0.39	1.51	1.30	1.80
PPT to the left (kg/cm^2)	1.42	0.36	1.40	1.22	1.69
Flexion (°)	58.93	10.17	58.00	51.75	65.66
Extension (°)	67.96	11.29	68.00	60.92	75.16
Inclination to the right (°)	42.79	5.92	41.33	39.00	48.16
Inclination to the left (°)	46.54	6.05	47.16	42.08	51.24
Rotation to the right (°)	80.29	10.14	79.83	74.41	85.00
Rotation to the left (°)	83.75	9.98	84.00	78.33	88.66
RMS_i to the right (%)	109.39	42.00	99.98	88.82	115.67
RMS_r to the right (%)	5.21	6.01	3.61	2.16	6.57
MF_i to the right (Hz)	71.40	11.90	70.86	63.50	77.74
MF_r to the right (Hz)	34.17	15.47	31.45	22.86	42.98
RMS_i to the left (%)	96.76	21.52	99.80	86.10	107.26
RMS_r to the left (%)	7.97	8.62	5.22	2.57	10.48
MF_i to the left (Hz)	68.05	12.80	67.88	61.10	76.29
MF_r to the left (Hz)	22.94	13.42	18.74	13.10	27.69

MF_i, median frequency of isometrics; *MF_r*, median frequency at rest; *NDI*, Neck Disability Index; *NRS*, Numeric Rating Scale; *PPT*, pressure pain threshold; *RMS_i*, root mean square of isometrics; *RMS_r*, root mean square at rest; *SD,* standard deviation; *SkT*, skin temperature.

Table 2. *Correlation Between SkT, Pain, Range of Motion, and Electromyographic Activity (n = 40)*

Outcomes	Left SkT (°C)	Right SkT (°C)
NRS at rest (score)	r_s = 0.171, P = .291	r_s = 0.158, P = .330
NRS at motion (score)	r_s = 0.076, P = .642	r_s = 0.139, P = .391
NDI (score)	r_s = 0.221, P = .171	r_s = 0.282, P = .077
PPT to the right (kg/cm^2)	r = -0.035, P = .832	r = -0.070, P = .666
PPT to the left (kg/cm^2)	r = -0.022, P = .894	r = -0.043, P = .791
Flexion (°)	r = 0.249, P = .122	r = 0.322, P = .043 [a]
Extension (°)	r = 0.214, P = .186	r = 0.086, P = .597
Inclination to the right (°)	r = -0.144, P = .375	r = -0.234, P = .147
Inclination to the left (°)	r = -0.278, P = .083	r = -0.285, P = .075
Rotation to the right (°)	r = 0.019, P = .906	r = -0.070, P = .666
Rotation to the left (°)	r = 0.018, P = .914	r = -0.070, P = .669
RMS_i to the right (%)	r_s = -0.040, P = .805	r_s = -0.162, P = .318
RMS_r to the right (%)	r_s = -0.232, P = .149	r_s = -0.447, P = .004 [a]
MF_i to the right (Hz)	r = 0.365, P = .020 [a]	r = 0.341, P = .032 [a]
MF_r to the right (Hz)	r = 0.135, P = .407	r = 0.105, P = .520
RMS_i to the left (%)	r = -0.069, P = .672	r = -0.046, P = .779
RMS_r to the left (%)	r_s = -0.288, P = .071	r_s = -0.290, P = .069
MF_i to the left (Hz)	r_s = 0.177, P = .276	r_s = 0.116, P = .474
MF_r to the left (Hz)	r_s = 0.573, P < .001 [a]	r_s = 0.427, P = .006 [a]

MF_i, median frequency of isometrics; *MF_r*, median frequency at rest; *NDI*, Neck Disability Index; *NRS*, Numeric Rating Scale; *PPT*, pressure pain threshold; *r*, Pearson correlation coefficient; *RMS_i*, root mean square of isometrics; *RMS_r*, root mean square at rest; *r_s*, Spearman correlation coefficient; *SkT*, skin temperature.

[a] Statistically significant association.

masseter and anterior temporal muscles and skin temperature. Another study carried out with temporomandibular disorder patients observed a positive association between skin temperature at the temporomandibular joints and the severity of the dysfunction.[33]

Regarding the correlation studies of individuals with neck pain, Lee et al[34] found significant correlations between skin temperature and the intensity of pain in the neck and shoulder region in patients with whiplash injury, noting an increased temperature in these places immediately after injury. In our study, no correlation was observed between pain and skin temperature. However, there is a central difference between the 2 studies: Lee et al[34] investigated patients with acute lesions, whereas the present study included participants with chronic neck pain. Furthermore, Lee et al[34] do not mention the presence or absence of myofascial trigger points in the muscles subjected to thermal evaluation.

Regarding electromyographic parameters, it was observed that the higher the RMS at rest, which is the baseline muscular electrical activity, the lower the skin temperature (negative association). Some authors emphasized in their studies a pathophysiological explanation for this result[35,36]: individuals with myofascial dysfunctions have a higher muscle activity at rest, resulting in increased intramuscular pressure and compression mechanics of the vessels vascularizing the muscle. Thus, over time, the smaller blood supply leads to a reduction in the skin temperature. In addition, another explanation is possible: increased muscle activity indicates more pronounced sympathetic action, resulting in reduction of peripheral flow with consequent reduction of temperature.[37] This increase in electrical activity of the upper trapezius muscle is related to another finding of this study: the lower the temperature, the lower the range of motion for cervical flexion. In other words, the lower temperature is related to increased muscle activity at rest, which in turn causes restrictions to the cervical flexion, as the trapezius is an antagonist of this movement.

The median frequency was another electromyographic parameter evaluated in this study, with a positive correlation being observed between the variables: the lower the skin temperature, the lower the median frequency at rest and with isometrics, which according to Merletti et al[38] and Edmondston et al[39] is because the muscle in fatigue has lower values than the median frequency. Other authors have observed that individuals with neck pain have a higher muscle fatigue when compared to control participants.[40,41] In these terms, the reduction in skin temperature at the upper trapezius with the presence of trigger points indicates a change in the blood supply going to this muscle[5,36] and, consequently, an inefficiency of aerobic metabolism. Thus, anaerobic metabolism is used by the body, resulting in an increased propensity for muscle fatigue.[2]

In light of these results—that the muscle in chronic dysfunction shows increased muscle activity at rest and therefore a reduced skin temperature and a greater susceptibility to fatigue—we suggest that clinical interventions directed toward patients with chronic muscle dysfunction employ resources that promote muscle relaxation and increase of blood flow, such as high-voltage electrical stimulation,[42] massage,[43] therapeutic ultrasound,[44] or low-level laser therapy.[45]

Conclusion

Patients with chronic neck pain who had reduction of skin temperature over myofascial trigger points in the upper trapezius muscle had reduced cervical range of motion for flexion, reduced median frequency at rest and during isometric contraction, and increased root mean square at rest.

Funding Sources and Conflicts of Interest

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Contributorship Information

Concept development (provided idea for the research): A.V.D.-F., R.R.d.J.G.
Design (planned the methods to generate the results): A.V.D.-F., R.R.d.J.G.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): R.R.d.J.G.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): C.E.G., A.V.D.-F., A.K.d.O.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.V.D.-F.
Literature search (performed the literature search): C.E.G., A.V.D.-F., A.K.d.O.
Writing (responsible for writing a substantive part of the manuscript): C.E.G., A.V.D.-F., A.K.d.O., R.R.d.J.G.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): A.V.D.-F., R.R.d.J.G.

Practical Application

- Infrared thermography, over myofascial trigger points, was related to the electromyographic activity but was not associated with pain in patients with neck pain.

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