

Integration of Thermography in Electroacupuncture Therapy

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Abstract

Purpose - Summary: This study analyzes the application of infrared thermography (IT) in the diagnosis and treatment of musculoskeletal pain (MSP) using electroacupuncture (EA). A case study was conducted involving a 40-year-old female patient with lordosis and impingement between the fifth lumbar vertebra and the first sacral vertebra. The follow-up of the electroacupuncture treatment was complemented with thermographic imaging, using a highly sensitive thermal camera (Flir E8) to detect thermal variations related to the patient's pain. In this context, the advantages of IT were compared with ultrasound in the evaluation of inflammatory processes and chronic pain. The findings indicated that IT is effective in identifying inflammation and monitoring treatments. Additionally, EA was shown to be effective in enhancing the therapeutic response by modulating neuronal function and reducing inflammation.

Regarding the results obtained, it was found that the combination of IT and EA allowed for precise diagnosis and personalized treatment, highlighting the complementarity of both techniques. Therefore, it is suggested that the integration of IT and EA can significantly improve outcomes in patients with MSP, providing a new perspective in the management of chronic pain and inflammation. Although further studies are recommended to consolidate these findings and expand their clinical application, this study underscores the importance of standardized protocols in the use of IT and the integration of complementary methods in the management of MSP, proposing IT as a non-invasive, cost-effective, and repeatable tool, suitable for children and pregnant women.

Moreover, it is noteworthy that this work was developed based on the parameters and recommendations of the STRICTA (2010) criteria, which internationally standardize the documentation of controlled trials of acupuncture.

Keywords: electroacupuncture / thermography / chronic pain treatment / imaging diagnosis / musculoskeletal pain / acupuncture.

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1 Introduction

The purpose of this work is to explain the relevance of infrared thermography (IT) in the diagnostic and treatment processes using electroacupuncture (EA) in patients with musculoskeletal pain (MSP)...

To begin defining the importance of infrared thermography (IT) in physical pain, whether chronic or acute, and its expressions in the body as temperature variations, we highlight the words of Nobel Prize winner (2021), Dr. David Julius [1], who states:

“What we are trying to understand are the molecular mechanisms underlying the sensation of pain and temperature. The receptors we have identified not only help us understand how we feel heat and cold but also provide new potential targets for the development of treatments for chronic pain.” [1]

Regarding the definition of IT in the field of medicine, it constitutes a complementary imaging study method that has the ability to detect temperature levels of the body surface by identifying and quantifying the radiation emitted by the body [2]. In this case, a highly sensitive thermal camera calibrated for human use is used, which makes the thermal variations visible and records them as images called thermograms through the use of specific software. However, it is worth noting that for this tool to become part of a presumptive diagnosis or the monitoring of medical treatment for various pathologies, further research is required to link these diseases with body temperature reactions.

Highlighting the properties that position IT in this field of application, [3], assert that it can be implemented as a complement to other diagnostic studies, while also presenting reduced costs and can be repeated as often as needed. At the same time, while other radiographic studies reveal structural abnormalities, thermography makes it possible to show “the physical expression of functional alterations that justify the patients’ symptoms” [4].

According to [4], IT has been implemented in medical fields since the 1960s but faced extensive questioning by the scientific community due to the lack of standardized protocols and, therefore, precision as a diagnostic tool; this led to it being disregarded at that time in favor of other medical technologies.

Currently, the protocols for the use of IT have been standardized, allowing its use in the medical context to be subject to strict quality standards [5], [6]. Therefore, it is maintained, along with [4], that:

“IT is a simple, non-invasive, bio-sustainable, and low-cost tool that provides valuable data to determine whether to continue with more specific studies. Since it does not use any form of radiation, it can be used in children and pregnant women without any risk. Furthermore, it can be repeated as many times as necessary, with guarantees regarding the repeatability of the results. This technique does not displace other diagnostic tests but rather complements them, providing the professional with more functional information regarding the pathology or lesions that patients suffer from.” [4].

On the other hand, body image thermograms are a tool that allows the identification of thermal variations and conditions and their relationship with various disorders, with their implementation based on thermal physiology according to cutaneous thermoregulation.

According to studies by [7], it is possible to affirm that the assessments regarding physiological thermal patterns acquire two characteristics, namely:

Quantitative Variations: “require determining the temperature of the study area and the existence of a temperature difference greater than 0.2-0.3 °C compared to the thermal area surrounding the studied zone” [7]. Qualitative Variations: “are observed in the presence of alterations in the thermal symmetry that characterizes the physiological thermal pattern” [7]. It should be noted that, unlike other radiographic studies, IT expresses in its images hypothermic states of tissues during inflammatory processes and, in hypothermic images, the processes of compression or degeneration [8] Therefore, its use as a complementary tool for interpreting symptoms of patients with MSP is a relevant method, as is its application in the monitoring of treatments using EA.

Regarding EA, a brief introduction to Traditional Acupuncture (TA) is necessary. Although both share the same base of specific points to intervene on the body, they differ in their way of stimulating them.

In TA, stimulation is performed by inserting thin, fine needles into acupuncture points, providing manual or mechanical stimulation of them, activating peripheral nerves, and triggering a series of responses in the Central Nervous System [9].

In EA, this mechanical stimulation adds an electrical stimulation, which can intensify the nervous response by activating more nerve fibers and increasing the release of neurotransmitters [10].

Another very clear difference is that EA, compared to TA, allows more precise control over the intensity, frequency, and duration of the stimulus. In this way, it makes it possible to adapt the treatment to the more

specific needs of the patient and the working condition. For this reason, electrical stimulation can increase the release of endorphins and neurotransmitters that have an analgesic effect, as well as provoke an increase in inflammatory molecules such as tumor necrosis or interleukins responsible for tissue repair [11], [12]).

In conclusion, EA achieves an intensification of the therapeutic response compared to TA, facilitating and reducing the number of sessions in the implementation of treatments for some ailments. It could be said that it is a comprehensive technique that takes advantage of the body's immunological mechanisms and neurotransmitters to its advantage, enhancing them and collaborating with the patient's well-being. Thus, this technique is not only relevant in the field of acupuncture but has also stood out in the management of MSP treatments.

Continuing in this line, it is worth highlighting that approximately 1.71 billion people suffer from MSP, with lumbar pain being the most frequent. These disorders represent one of the main causes of disability worldwide, greatly limiting mobility, causing a decrease in work capacity, and reducing the ability to participate socially [13].

MSP affects muscles, bones, joints, tendons, and ligaments of the human body. These pains can have various causes, ranging from sudden injuries, such as fractures or sprains, to chronic conditions like arthritis or fibromyalgia. Also, one of the most well-known conditions originating MSP is stress. Likewise, certain habits such as intense physical activity, poor posture, aging, and a sedentary lifestyle can contribute to the manifestation of MSP. Consequently, many MSP symptoms may not be properly diagnosed and, therefore, may not receive the proper treatment [14], [15].

According to their classification, pain can acquire the following characteristics:

Acute pain is sudden pain, usually associated with recent and spontaneous injuries, such as fractures, sprains, or strains. This type of pain is associated with the activation of nociceptors, which are pain receptors in the injured tissues, triggering a series of neurochemical and neurophysiological responses to locate the pain and aid in healing and restoring health [16]. On the other hand, chronic pain persists over time and can be related to medical conditions such as arthritis, fibromyalgia, or neuropathic pain. Chronic pain can involve neuroplastic changes in the central and peripheral nervous systems, which increase or perpetuate the amplification of pain signals. Continuing with the classification, there can also be localized or generalized pain. Concerning the former, the pain affects a specific and particular region that may be a joint, muscle, or bone or the result of a localized injury, contracture, or specific inflammation. In contrast, generalized pain can affect various parts of the body in a wandering manner, such as in the case of fibromyalgia or one or more Trigger Points (TP), where one area of the body is affected, but the pain spreads to different areas. On the other hand, the psychological impact that unfolds in chronic MSP is highlighted [17], [18].

In summary, the types of pain can be summarized as follows:

Acute pain: localized pain associated with recent injuries. Chronic pain: persistent pain associated with medical conditions. Localized pain: pain felt in a specific area of the body.

Generalized pain: pain that extends to multiple areas of the body. It is emphasized that, concerning EA intervention in the treatment of all types of pain, the studies by [19] emphasize its effectiveness since the cause of MSP can be a bone, joint, or muscular disorder, an injury to the tendons, ligaments, or synovial bursae, or a combination of these [20].

EA exerts important biological mechanisms in the body for MSP. Like the release of endorphins, which are the body's natural neurotransmitters that act as an analgesic [21]. These endorphins help reduce pain, causing a feeling of well-being in the patient. On the other hand, electrical stimulation of acupuncture points can modulate neuronal activity in the central and peripheral nervous systems, influencing pain improvement.

In this regard, the reduction of inflammation in some studies has suggested that EA may reduce inflammation in muscle and joint tissue by modulating pro-inflammatory and anti-inflammatory cytokines, helping to relieve pain due to inflammation [22], [23]).

Another important aspect of electrical stimulation at acupuncture points is that it can promote local vasodilation, improving blood flow to the affected area. This can facilitate the delivery of nutrients and oxygen to the injured tissues, as well as the removal of waste products, contributing to the recovery of the injured tissue. In this sense, it is important to deepen research, as it has been detected that the elevation of vasodilation is what is perceived with IT, specifically with prostaglandin [24]; [25]).

Prostaglandins are a class of bioactive lipids derived from arachidonic acid through the action of cyclooxygenase enzymes (COX-1 and COX-2). They play crucial roles in a variety of physiological and pathological processes, including inflammation, regulation of blood flow, coagulation, and pain perception [26].

Prostaglandin, especially E2 (PGE2), are key mediators in the inflammatory response. They act in

both the early and late stages of inflammation, facilitating vasodilation, increasing vascular permeability, and promoting the arrival of immune cells at the site of injury or infection [27]. Thus, PGE2 induces the dilation of blood vessels toward the affected area. This not only provides an increase in the nutrients and oxygen needed for tissue repair but also facilitates the entry of immune cells such as leukocytes to combat the infection or injury.

In conclusion, prostaglandin is essential in regulating inflammation and the immune response, and its ability to induce vasodilation and increase vascular permeability significantly contributes to the rise in the temperature of affected tissues. These effects are fundamental to facilitating healing, although their dysregulation can lead to chronic inflammatory conditions and persistent pain.

This translation maintains the content and context of the original text, focusing on the integration of thermography in electroacupuncture therapy, its application, and its effects on musculoskeletal pain.

The reference you provided for David Julius's acceptance speech at the BBVA Foundation Frontiers of Knowledge Award in Biomedicine appears to be accurate. David Julius received this award for his research on the molecular mechanisms underlying pain and temperature sensation, which has significant implications for developing new treatments for chronic pain. The speech and related materials, including videos, are available through the official BBVA Foundation website. However, I could not directly verify a specific YouTube link in the search results (Premios Fronteras).

2 THEORETICAL FRAMEWORK

Salvador Quiroz, founder of Neurophysiological Acupuncture, emphasizes, in his research, the use of AE in inflammatory treatments. Hence he maintains that: "Neuromodulation with AT or AE is used by millions of people to control pain, inflammation and restore physiological homeostasis during the disease" [12]

In the specific case of AE, one of the first and most significant moments regarding the popularization of acupuncture in the West was when James Reston, a New York Times journalist, reported his experience in AE to relieve postoperative pain after surgery in China. That generated considerable interest and led to more Western health professionals starting to investigate acupuncture from a scientific perspective.

In the 1980s, WHO published a review on acupuncture highlighting its potential in treatments of various conditions and further promoting scientific research. Subsequently, in 1990, a study conducted by Vickers et al., (1997) [28] evaluated the effectiveness of acupuncture in the treatment of chronic pain through a systemic review. This was one of the first studies that applied the rigorous methodology of MBE (evidence-based medicine) to acupuncture, marking an important milestone in its integration into evidence-based medicine.

This last investigation, by Vickers and Edzard (1997) [28], was the first to be practiced under the protocols that were exposed in Guyatt GH's article entitled "Evidence-based medicine. [29]. This article presents a new paradigm of practice, which focuses on the use of the best scientific evidence available, to make medical decisions. This approach contrasted with traditional medical practice, which was often based more on personal experience and expert opinion, than on rigorous scientific evidence. This involved the recognition of three fundamental aspects in the MEB along with acupuncture, namely:

- Improves the quality of care: using the best evidence to optimize treatment and medical care.
- Reduction of clinical variability: since it minimizes the disparity in the treatments offered to patients with similar conditions.
- Promotion of a more ethical and efficient medical practice: because it makes informed decisions that benefit the patient in the best possible way, avoiding unnecessary intervention.

According to the survey carried out on the practice of AS in musculoskeletal inflammation processes, current studies are evident that propose that this practice intervenes in the modulation of inflammation and the creation of neural networks, activating inflammatory molecules related to tissue repair. Particularly, the activation of Prostaglandin E2, Cyclooxygenase 2 (COX-2) and β -endorphin has been observed in response to AE [30]. The inflammation induced by AE has been observed by hyperradiation (temperature elevation) in thermography, which can be consulted in recent studies [31].

It should be noted that, by including controlled inflammation, the production of prostaglandin and COX-2 increases, while β -endorphin decreases. It follows that, during the session, the patient may experience initial

pain, however, interleukins and tumor necrosis factors (TNF) increase to facilitate the recovery of tissue [32].

In current Rehabilitation Medicine, various techniques are used that have demonstrated their effectiveness in the repair and rehabilitation of tissues in musculoskeletal pathologies. One of these techniques is ultrasound-guided percutaneous neuromodulation, which has been shown to be highly effective in the treatment, not only in the type of current used, but also in the use of the ultrasound, as a guide for the therapist who modulates through a dry puncture needle, on the peripheral nerve.

Diagnostic Studies: Differences between Ultrasound and Clinical Thermography

In the field of diagnosis and treatment of musculoskeletal disorders, thermography and ultrasound are key non-invasive tools that offer different approaches to evaluate these conditions. From the diagnostic perspective, this comparison highlights the capabilities and limitations of both modalities in the detection and management of chronic pain and the importance in prevention.

Medical Thermography

Advantages:

- Detection of thermal variations and chronic pain: thermography stands out for its ability to identify thermal changes in the skin that are indicative of inflammation, vascular dysfunction and chronic pain. According to research by David Julius, [1], thermal receptors in the skin play a crucial role in the perception of pain. Hence, thermography allows to observe these thermal variations, facilitating the early identification of chronic pain patterns that may be indicative of underlying disorders.
- Sensitivity to external factors: thermal readings can be influenced by the patient's ambient temperature and recent physical activity, which can affect the accuracy of the image and make it difficult to interpret the results.
- relative specificity: although thermography can detect areas of thermal changes, these anomalies are not always specific and can be related to a variety of conditions, which makes the therapist make an inadequate clinic.

Medical Ultrasound

Advantages:

- High resolution of soft tissues: ultrasound provides detailed images of muscles, tendons and ligaments, allowing an accurate evaluation of their structure and function. It is mainly useful for identifying specific lesions and guaranteeing the integrity of soft tissues in real time.
- Guide for therapeutic interventions: it is a key tool to guide therapeutic injections and other interventional procedures, improving the accuracy and safety of these treatments.
- Wide availability and effective costs: ultrasound is accessible and relatively inexpensive compared to other advanced imaging modalities, which makes it a visible option for daily clinical practice.

Disadvantages:

- depends on the operator: the quality and accuracy of the ultrasound images depend largely on the operator's experience and the high cost of the equipment. This can result in significant variations in the quality of diagnosis and images among different professionals and centers.
- Limitations in tissue penetration: ultrasound has a limited penetration in bones and deep areas according to the transducer, which implies that its work area will depend on the size of it.
- Subjectivity in interpretation: although less subjective than thermography, the interpretation of ultrasound images can also vary and requires specialized training to properly distinguish between normal tissues and pathologies.

Thermography and ultrasound are complementary tools in the diagnosis and treatment of musculoskeletal disorders. According to the above, it could be said that thermography, with its unique ability to detect superficial thermal variations, is particularly valuable in the early identification and management of chronic pain, allowing a non-invasive and continuous evaluation of inflammatory processes. This is especially relevant in light of the research of [1] that underlines the importance of thermal receptors in

the perception of pain and the critical role played by temperature variations in the pathophysiology of chronic pain.

On the other hand, ultrasound offers a higher anatomical resolution and is essential for the precise evaluation of specific lesions and the guidance of therapeutic procedures. Its ability to evaluate musculoskeletal functions in real time makes it an indispensable tool in clinical practice.

In conclusion, although ultrasound is crucial for detailed diagnosis and intervention in musculoskeletal disorders, thermography is valid for the detection of inflammatory processes and chronic pain. Likewise, the integration of both modalities can provide a more complete and accurate evaluation, significantly improving care and long-term results in the treatment of musculoskeletal disorders. Hence, recent research has found the complementarity between thermography and ultrasound, and that in many cases there are no significant differences in the diagnosis obtained [33], [34].

As the permanent search for the improvement of diagnostic processes, it is important to have a visual and objective guide to determine the severity and specific location of the ailment in the patient's body. In this sense, clinical thermography plays a fundamental role as a primary guide, since it provides precise information about the site of the inflammation / pain of the patient, which is decisive for the precise placement of needles and the electrical stimulation necessary for controlled inflammation and a speedy recovery of the injured tissue. In addition, this technique allows you to consider complementary strategies, such as distal acupuncture, which consists of placing needles away from the pain zone to obtain a systemic effect.

A contribution of recent research, such as those carried out by [35] and [36], have demonstrated the effectiveness of combining distal acupuncture with local acupuncture to improve therapeutic results. Likewise, the effectiveness of techniques such as YNSA acupuncture [37] has been studied to collaborate with the treatment from electroacupuncture locally.

3 MATERIALS AND METHODS

For the present study, the case of a 41-year-old woman who has a diagnosis of lordosis with clamping in lumbar vertebra 5 and sacral 1 was raised.

Participant:

- Sex: Female
- Age: 41
- Height: 165 cm
- Weight: 70 kg
- Body mass index (BMI): 25.7 kg/m

Medical Condition:

- Main Symptom: lumbar pain
- Duration of the symptom: 6 months
- Intensidad del dolor: 8 en la escala de 1 a 10
- Characteristics of pain: the pain radiates in the form of heat, burning and tingling from the gluteus to the left leg, sometimes reaching the heel and passing through the Achilles tendon.
- Other affectations: the patient presents another symptomatology detected from the thermographic diagnosis of the complete body that are not part of this study, but the general state of health of the same is important. This symptomatology is associated.

Previous Treatment:

- The patient was medicated with anti-inflammatory drugs (Flexicamin B12), taking a tablet every 12 hours.

- No improvement in symptoms was observed after treatment with Flexicamin B12.

Data collection methods:

- Clinical interview: through the interview with the patient, the intensity of pain was evaluated using a visual analog scale (VAS) where 1 represents the lowest pain intensity and 10 the highest. The irradiation of the pain was documented.
- Anthropometry measurement: the height and weight of the patient were measured using a scale and a standard stadiometer.
- Spinography: the scenography was performed using a digital X-ray equipment, following standard protocols to obtain lateral images of the spine.
- Clinical thermographic images: clinical thermal images were performed to identify and evaluate the most inflamed points (of greater heat/pain) and acupuncture points relevant to the treatment of pain. It is also highlighted that the regulations for taking images, both in positions, distances, etc. were following the regulations established by the SATEM.



Figure 1: Spinography

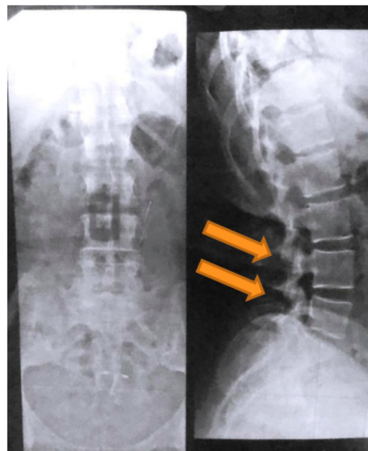


Figure 2: Lumbar X-ray, Lumbalgia. The arrows indicate the place marked by the traumatologist of low back pain L3, L4, S1, the same place shown in the thermography.

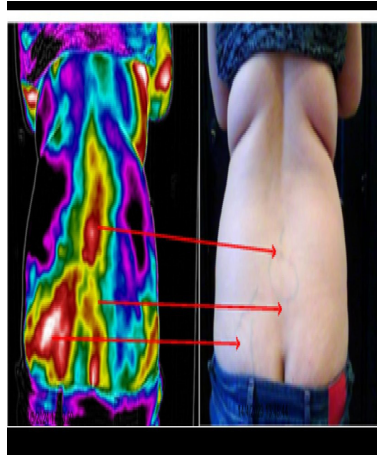


Figure 3: Thermographic image vs. digital image. Comparison of the infrared thermography of the patient's lumbar region with its corresponding digital image. In the image on the left, the thermography reveals hyperthermic areas (hyper radiance = red and white color) in the lumbar and left gluteal region, suggesting inflammation in these areas. In the image on the right, the same anatomical region is observed, where the areas where the patient has reported pain have been marked with fiber lines. This comparison highlights the correlation between the clinically reported areas of pain and the thermal alterations detected by thermography.

- Treatment record: the previous treatment with Flexicamin B12 that the patient performed was documented, specifying the dose and frequency, as well as the lack of improvement in the symptoms. In methodological terms, the criteria and rules established for controlled acupuncture studies, called STRICTA recommendations (2010), were followed.
- Preparation of the patient: before taking thermographic images, a meticulous preparation of the patient was carried out. Detailed information was provided on the treatment to be carried out, as well as the need to perform thermographic images and their potential inclusion in future investigations. The participant signed an informed consent, which detailed the procedures, risks and rights in relation to her voluntary participation in the study.

Environmental Conditions: The thermographic images were taken in a controlled environment, replicating the conditions established by the ISO standards of clinical medical thermography, having a strict review by the SATEM Professional Commission. A personal office of approximately 4 meters X 4 meters was adapted for the purpose (see Figure 6).

Environmental conditions included:

- Room temperature: 23 °C.
- Maximum 2 people in the room.
- Use of thermohygrometer.
- Air speed < 2mts/sec.
- Controlled humidity below 60
- Opaque windows to prevent the entry of external light.

Configuration of the thermography camera: The positioning of the thermography camera was standardized to ensure consistency in the measurements with an Emissivity of 0.98%. The patient was placed in specific positions and the movement was minimized during the acquisition of the images and thermal video. The thermographic image was recorded using a Flir E8 camera (76,800 pixels), using the Rainbow HC and Midgreen color palette.

Acquisition of thermal images: Thermographic images were acquired with a Flir E8 camera following a protocol Standardized, capturing images of the regions of interest (ROI), with a focus on the anatomical

regions relevant to the rehabilitation study. Multiple measurements were made to obtain reproducible and reliable data. Along with this, an ITO 160 Electroacupuncture equipment was used.

Electroacupuncture:

- Maximum output voltage $16\text{ V} \pm 25\%$
- Maximum output current $32\text{ mA (peak)} \pm 25\%$ ($500\ \Omega$ load).



Figure 4: Thermographic image before treatment, thermal image before starting the treatment of the lumbar area, hip and lower limbs. Marked with a Roi the affected area (hyper radiant) and pain manifested by the patient.

- Timer: maximum of 60 minutes ± 1 min.
- Output methods: Constant, Burst, Wave, Fast + Slow, Sweeping and Random Program.
- Filiform Acupuncture Needles of 25x25.
- In the puncture with acupuncture, the visualization of the hyperthermal zone (hyperradiant) that corresponded to the maximum inflammation of the low back pain was used.

4 RESULTS

Following the recommendations and criteria regarding the presentation of controlled acupuncture studies (STRICTA, 2008, 2010), the presentation of the case study is detailed below. It is noteworthy that the quality criteria of the study referred to were contemplated both for the design and planning of the study, as well as for its subsequent publication.

In this case, the effectiveness of infrared thermography as a visual guide to AD was evaluated in a 41-year-old patient diagnosed with lordosis and lumbar clamping and The intervention consisted of an AE treatment protocol applied in specific points related to the DME and in the use of IT to monitor thermal changes associated with inflammation and therapeutic response.

Acupuncture concept: Threaded needles of 25x25 types of Korean mango were used, Dong Bang brand with applicator. The puncture technique was transfixing, rather than perpendicular, due to the muscle tension of the paravertebral and lumbar square muscles, areas in which the patient had significant pain. The transfixing technique, used in Traditional Chinese Acupuncture, allows you to connect several Acupuncture points with a single one.

Insertion technique: 10 Acupuncture Needles were placed Dong Bang 25x25 Korean mango) using the transfixing technique, completing the insertion up to the handle. The objective was to minimize muscle tension and pain at the points Bladder 23 (Shenshu) in transfixing form towards Vegja 24 (Qiaishu), and Bladder 25 (Dachangshu) in transfixing form towards Bladder 26 (Guanyuanshu) bilaterally In addition, 6 25x25 needles were inserted perpendicular, almost up to the handle, in the left gluteus area,

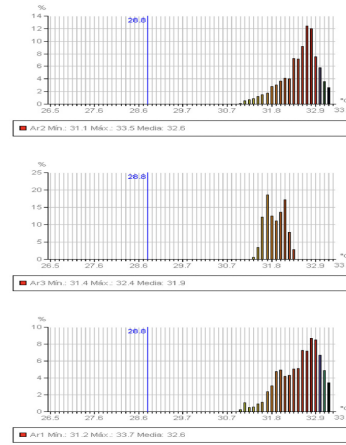


Figure 5: histogram



Figure 6: Thermographic image after treatment, Los Rois were located in the same places affected and pain (hyper radiant), and mark a decrease in the temperature considered, announcing the improvement.

and the structure of the gluteal muscle, seeking to induce the sensation of qi (scorching, numbness, etc.).

Treatment modality: the treatment consisted of a 30-minute session once a week for four weeks. Electroacupuncture was performed with an ITO ES-160 equipment. It was applied in the Shu points of Acupuncture following the following protocol:

- First Phase:
- Frequency 4HZ.
- Mode: intermittent pulse bursts.
- Pulse width: 400 microseconds
- Duration of the stimulus: 10 minutes.
- Second Phase:
- Frequency: 60HZ.
- Mode: pulses of gradually ascending and descending currents.
- Pulse width: 100 microseconds.

- Duration of the stimulus: 10 minutes.
- Third Phase:
- Frequency: 4 HZ.
- Mode: gradually upward and downward current pulses.
- Pulse width: 100 microseconds.
- Duration of the stimulus: 10 minutes.

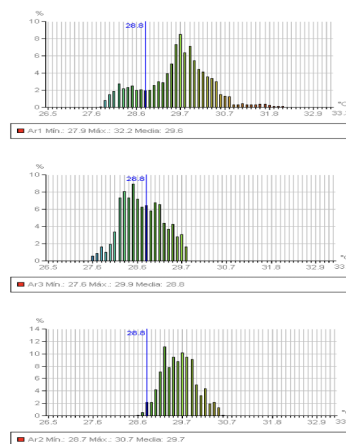


Figure 7: histogram

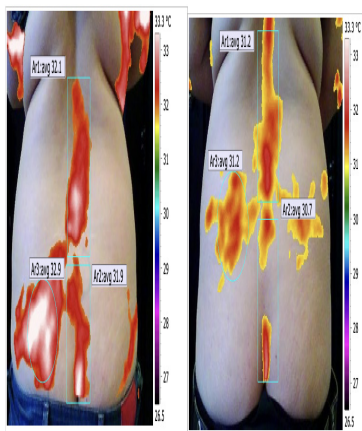


Figure 8: Close-termographic image in the area of pain before (figure left side) and after treatment (figure right side) comparative of the painful zone before and after treatment. The Rain.Pal palette with thermal fusion was used to denote the affected area, where the decrease in temperature corresponding to the pain is clearly observed.

The combination of pulse burst modes and gradually ascending and descending pulses could influence the mechanisms of pain relief. It should be noted that the patient, at the end of the session and the following two or three days, could identify that the pain increased, but decreased considerably after the week. Therefore, it was suggested to follow up the treatment once a week, generating favorable results and pain relief, expressed by the patient.

Simultaneous interventions: Additional interventions that could alter the treatment improvement parameters were avoided. Hence, moxibustion was not performed, since it modified the temperature of the treated area, hindering measurements and thermographic monitoring. Herbal patches were also applied nor were

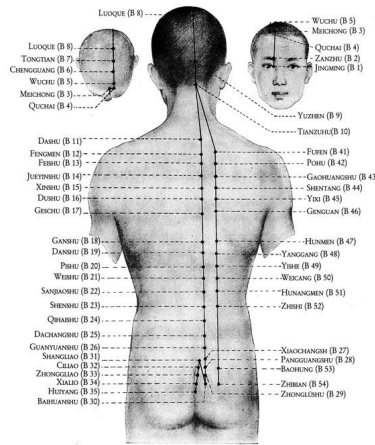


Figure 9: Points used: Bladder 27 (Xiaochangshu), Bladder 25 (Dachangshu) and points outside meridians following the hyper radiance of the left gluteus.



Figure 10: Approximate dimensions of the thermographic laboratory (office).

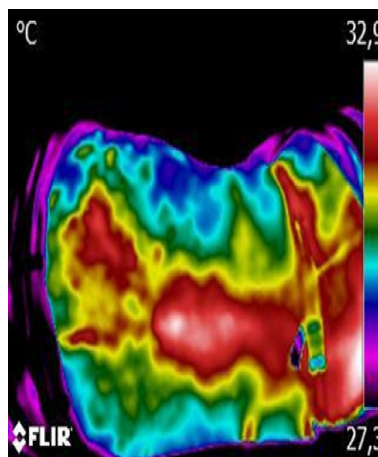


Figure 11: Imagen térmica de la paciente en la camilla en decúbito lateral derecho, la imagen térmica muestra la hipertermia de la zona lumbar que se irradia al glúteo izquierdo, lo que concuerda con el dolor referido por la paciente.

exercises such as yoga, kinesiology or stretching recommended. The only additional recommendation was to modify the diet under the supervision of a Bachelor of Nutrition, to try to reduce the patient's weight

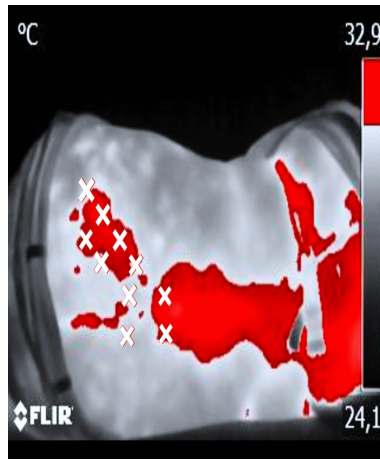


Figure 12: Thermogram with alarm palette, In the thermal image presented, the specific points where the insertion of acupuncture needles was decided have been marked with "X". These points correspond to the Shu points of the back and to areas where significant inflammation was identified, evidenced by hyperradiance in the gluteal region. The identification of these areas of inflammation was based on the abnormal temperature patterns captured by thermography, highlighting areas with greater blood flow and inflammatory activity.

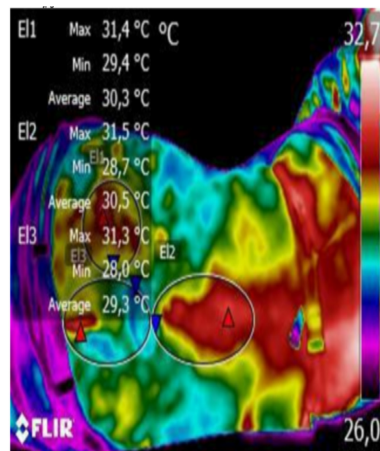


Figure 13: Thermal image of the patient before electro acupuncture, the patient was placed in the right lateral decubitus to optimize access to the anatomical areas of interest and ensure comfort during the procedure and the capture of thermographic images and electroacupuncture treatment. This position also facilitates the homogeneous distribution of the respective needles and electrodes, minimizing the involuntary movement that could interfere with the therapy. The acupuncture points were identified in correspondence with the areas of inflammation and pain referred by the patient. High, medium and minimum temperature measurements were obtained in each selected area to evaluate the local inflammatory response and adjust the current intensity according to the patient's specific therapeutic needs, fundamental data to monitor inflammation and to plan future therapeutic interventions.

without altering the temperature and thermal measurements of the treatment.

Control interventions: for this trial no control or comparative interventions were performed with respect to other patients or similar treatment.

Results: pain reduction. As explained above, the visual analog scale (EVA) was used to measure pain before and after treatment. The results showed a significant decrease in pain score, going from a value of 8/10 to 3/10 after four weeks of treatment, one session per week. This reduction is indicative of a relevant clinical improvement in the perception of pain by the patient and the number of sessions, without the need to see the patient on a daily basis, otherwise, with a weekly frequency

Thermal Changes: the IT revealed a remarkable increase in temperature in the session with AE, indicative of the increase in vascularity that leads to increased inflammation [38] considered by the increase in

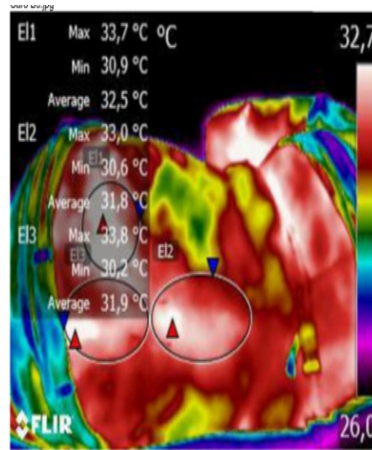


Figure 14: Thermal image after the electro acupuncture session, the post-session thermal image of electroacupuncture reveals a significant alteration in the distribution of skin temperature, showing an increase of approximately 2 °C in the average temperature of the treated areas. This thermal increase suggests an improvement in blood perfusion and an elevation of local vascularization as a result of the application of electroacupuncture. These changes are consistent with a favorable physiological response that could contribute to the reduction of inflammation and the relief of pain in the affected tissues.

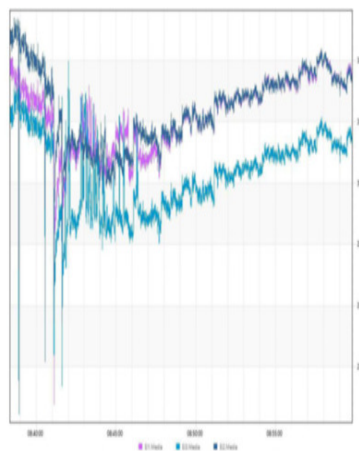


Figure 15: Thermic histogram, the histogram corresponds to the thermographic images of the lumbar and gluteal region (Figures 4 and 6) where a significant increase and in detail of the surface temperature is shown in the areas where the regions of interest were applied (Rois). In these areas, selected for their correlation with the pain and treatment points reported by the patient, an average thermal elevation of almost 2 °C post-treatment was observed. This increase in temperature is indicative of an inflammatory response that could reflect a healing process or a decrease in muscle stiffness. The thermal results suggest a positive physiological response to the electroacupuncture intervention, which is consistent with the clinical improvement reported by the patient.

prostaglandin and tissue repair molecules, which the tissue requires for its speedy recovery. In this context, the patient showed pain at the end of the session time and for the next three days. After that period, the patient recorded a considerable improvement, reduction in pain and increase in flexion and extension of the spine. The latter shows a considerable restoration of motor function in the lumbar region.

Side effects: no significant adverse side effects related to the application of AD or the use of IT were observed, suggesting that these techniques are safe and well tolerated by the patient.

Comparison of thermal images: thermographic images before and after treatment showed a decrease in hot spots (hot spot and histograms) and a more homogeneous distribution of the temperature of the lumbar region, indicating a positive response to treatment.

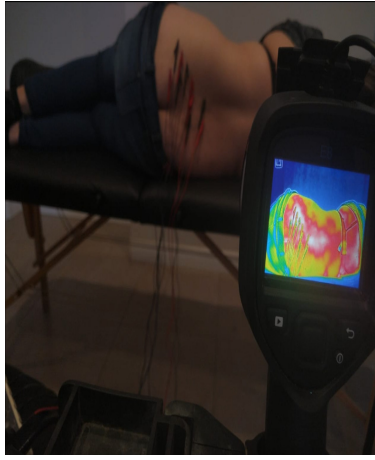


Figure 16: Photograph of thermal monitoring while electro acupuncture.



Figure 17: specific points

5 DISCUSSION

The results of this study show that the combination of IT as a visual guide and AE as a means of treatment is effective for the treatment of DME, specifically in patients with conditions such as lordosis and lumbar clamping. The significant reduction in pain score and the improvement in functional mobility observed in this study suggest that these combined techniques can be valuable tools in the clinical management of these conditions, by cost of materials and by time in reducing the improvement of the symptom, resulting in a non-invasive technique and without radiation.

On the other hand, the AETSA report [39] comes to reaffirm previous reports of the same organization, as well as the scientific evidence necessary to consider acupuncture (in general terms), as an effective tool for chronic pain, even when there is still a moderate to low quality of such research, given that the use of STRICTA standards has not been universalized internationally.

Hence the need to promote scientific-academic productions based on these quality criteria in the field of acupuncture and articulate them with clinical studies and the use of thermography.

In relation to the application of thermography, in the case studied there is a decrease in the temperature observed in thermographic images, which indicates a reduction in inflammation (Fig 6), which is consistent with previous studies that have demonstrated the effectiveness of electroacupuncture in the modulation of inflammatory processes and the relief of pain [19] [21]. Therefore, thermography, as a non-invasive tool, provided an objective way to monitor these changes, which adds an additional layer of validity to the finding of the Thermoguided E-Acupuncture technique.

A comparison with previous studies shows consistency with the existing literature. For example, studies

of [20] and [2] have documented the effectiveness of electroacupuncture in reducing pain and inflammation, although these studies did not use thermography as a guide to monitor thermal changes.

The [20] trial showed that electroacupuncture produced a significant reduction in pain and inflammation. In their study, carried out in rats, the authors observed that acupuncture, by stimulating specific points, caused the release of endogenous neurotransmitters and modulators, which resulted in analgesic and anti-inflammatory effects. The results indicated by Ahmed are in agreement with what was observed in the present case study. Hence, it can be said that AE not only reduced pain but also improved functional mobility in the patient with lordosis and lumbar clamping. Likewise, the addition of thermography in this study provides visual and quantitative evidence of the thermal changes associated with inflammation, which strengthens the arguments about the effectiveness of AS documented by [20].

On the other hand, [2] carried out a systematic review that evaluated the effectiveness of acupuncture for various chronic pain conditions, including musculoskeletal pain. And its results indicated that acupuncture was more effective than placebo treatments in reducing pain, even more than some medications. Although they highlighted the need for clinical trials with better methodological quality. In this sense, the study of the analyzed case, contributes to these discussions the demonstration not only of the effectiveness of AS in the reduction of musculoskeletal pain, but also the use of thermography to objectively validate and monitor the therapeutic effects of AD, addressing some of the methodological limitations pointed out by [2].

The patient's case study of this trial adds significant value by providing visual and qualitative evidence of the therapeutic response, highlighting the importance of using tools such as thermography to improve the accuracy and validity of AE interventions.

It is important to note the limitations of this study, including the absence of a control group and the evaluation of a single patient, which limits the generalization of the results. Future research should consider designs with quantitatively more representative samples and controlled comparisons to validate these findings.

6 DISCUSSION: Integration of Thermography in Acupuncture and Electrostimulation

The incorporation of thermography into the clinical practice of acupuncture and electrostimulation represents a significant advancement in the diagnosis and treatment of various pathologies, particularly in the musculoskeletal domain. This technology, which combines a non-invasive, contactless, radiation-free, and highly sensitive approach, positions itself as an ideal complementary tool for modern medicine. Its ability to detect and document thermal alterations in real time offers unique benefits for both patients and healthcare professionals.

From a clinical perspective, thermography enables simultaneous and precise evaluation of multiple conditions and organs in a single image, a capability that is uncommon with other diagnostic methods. Additionally, its dynamic use allows for real-time observation of physiological changes during procedures such as electrostimulation and acupuncture, facilitating a better understanding of the mechanisms of action and the body's response to treatment. This characteristic enhances the personalization of interventions and allows for immediate adjustments to therapies, optimizing therapeutic outcomes.

E-Acupuncture Thermography, a technique that combines acupuncture with thermography, serves as a clear example of technological innovation in complementary medicine. This approach enhances the sensitivity and specificity of treatments, yielding more predictable results aligned with clinical expectations. Its capacity to precisely identify the most relevant acupuncture points and monitor therapeutic effects in real time reinforces the scientific foundation of its application, particularly in managing inflammatory pathologies and musculoskeletal pain.

From the patient's perspective, thermography fosters a better understanding of their condition through intuitive thermal images. Unlike more complex diagnostic methods such as magnetic resonance imaging or electrocardiograms, the color patterns in thermographic images are easily interpretable, fostering trust and encouraging treatment adherence. Its safety profile, being a painless and radiation-free method, makes it suitable even for vulnerable populations, such as children, pregnant women, and individuals with sensitive clinical conditions.

In conclusion, the integration of thermography into the practice of acupuncture and electrostimulation not only optimizes diagnostic precision but also promotes an evidence-based approach aligned with modern medical standards. This development drives therapy personalization and strengthens the scientific credibility

of complementary medicine, paving the way for innovation in managing musculoskeletal pathologies and other physiological imbalances.

Potential Applications and Future Perspectives The use of technologies such as thermography applied to acupuncture and electrostimulation could become a gold standard in complementary medicine, integrating more frequently into clinical practice and reinforcing its acceptance within the international scientific community. Future studies should focus on further validating its effectiveness through controlled clinical trials, exploring its impact on different populations and clinical conditions.

7 CONCLUSION

The results obtained in this article suggest that the combination of infrared thermography (IT) as a visual guide and electroacupuncture (AE) as a treatment can be effective tools for the management of musculoskeletal pain (MDE), especially in conditions such as lordosis and lumbar clamping. The most prominent technical findings are presented below:

With regard to Electroacupuncture:

- Frequency and intensity modulation: specific therapeutic effects were observed depending on the configuration of the frequency and intensity of the applied electric current (low frequency (2HZ) and high frequencies (60 HZ)), where they were shown to be effective in the modulation of inflammation and pain. In the first days, the pain increases due to the activation of inflammatory molecules but, as the days went by, the relief of pain and the increase in body mobility demonstrated the effectiveness of recovery.
- Precise location of acupuncture points: the accuracy in the location of acupuncture points, optimized by IT, improved the effectiveness of the treatment. A direct correlation was observed between the precision of the stimulation and the reduction of the pain perceived by the patient.

In relation to Infrared Thermography (IT):

- Detection of hyper radiant zones: IT allowed the identification of areas of hyperthermia associated with inflammatory processes and nerve dysfunction. These areas were used as a guide for the application of EA, which resulted in a more precise and focused intervention.
- Real-time monitoring: IT's ability to provide real-time images facilitated the continuous evaluation of treatment effects, allowing immediate adjustments to AE therapy in response to observed changes.

8 THERAPIST QUALIFICATION

The Thermoguided E-Acupuncture technique was designed and applied by, who writes, Diego Carmona, a professional with studies in Traditional Chinese Medicine with an orientation in Acupuncture (2010), completing the 2300 hours of theoretical study and 900 hours of clinical practice. Subsequently, he was trained in different areas, highlighting the Diploma of Neurophysiological Acupuncture and Psychoneurobiomodulation by Percutaneous Nerve Stimulation (2019), with a duration of 120 hours, at the Institute of Sciences and Integrative Medicine S.C. under the direction of Dr. Salvador Quiroz González, director of ICIMI (Mexico). He also specialized in Functional Diagnosis in Clinical Thermography (2020) with Prof. José Valdez (Portugal) with 225 hours, Clinical Thermography (2021) level I and II by Dr. Marcos Leal Brioschi and Clinical Medical Thermography SATEM (Argentine Society of Medical Thermography) by Dr. Marcelo Almada (2020). He is currently a member of the Thermoguided Acupuncture Commission at SATEM, for the research and/or treatments carried out in Clinical Thermography and Acupuncture, being currently the only non-medical professional member of that commission.

9 TREATMENT REVIEWERS

Sebastián Reyes Martínez, studies in Kinesiology at the University of Chile (2015), Acupuncture at the University of Santiago de Chile (2017). Electroacupuncture Specialist and Director of the KineShen School.

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Dr. Marcelo Almada, specialist in Medical Thermography and Thermologist from the University of Sao Pablo, Brazil, Specialist in General Surgery. Repair and Specialist in Phlebology and Lymphology, as well as Pte. of SATEM (Argentine Society of Medical Thermography).

Declaration of Conflict of Interest

The authors declare that there are no conflicts of interest related to the publication of this article.

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