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DIAGNOSTIC METHODS: Mentored Research: Cross-Sectional Study

Superficial temperature and pain tolerance in patients with chronic low back pain

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ABSTRACT

Introduction: Low back pain is a common and very prevalent disease and can impose limitations that negatively impact patients. The objective of this study was to verify and compare the association between lumbar superficial temperature and pressure pain tolerance thresholds in individuals with chronic nonspecific low back pain and healthy controls.
Methods: This was a cross-sectional observational study involving 38 individuals with nonspecific chronic low back pain and 19 healthy controls. Volunteers underwent thermographic (infrared sensor), pain perception (visual analog scale), and pressure pain tolerance thresholds (algometry) evaluations in the right and left paravertebral muscles and L4-L5 ligament.
Results: A lower tolerance to pressure pain was found in patients compared to controls at all evaluated sites ($p \leq 0.003$). Superficial temperature was significantly higher in the sites evaluated in the low back pain group ($p < 0.001$). In patients with low back pain, pain perception was weakly and inversely correlated with pressure pain tolerance ($r = -0.31$; $p = 0.05$) and moderately correlated to the temperature of the evaluated sites ($r = 0.51$ to 0.59, $p \leq 0.001$). Also, an inverse and weak to moderate association was observed between pressure pain tolerance thresholds and temperature in patients only ($r = -0.36$ to -0.49; $p \leq 0.02$).
Conclusion: Individuals with low back pain have lower pressure pain tolerance thresholds and higher superficial temperature in the lumbar region when compared to healthy individuals. The associations observed show that the higher the pain perception, the lower the pain tolerance and the higher the superficial temperature in the lumbar region. Also, the higher the temperature, the lower the pain tolerance.

1. Introduction

Chronic low back pain is a common disease, with prevalence of 4.2–14.7% in the Brazilian population (Nascimento and Costa, 2015). About 80% of all adults will eventually experience it in their lives, and more than one episode occurs in up to 50% of people, making this disease a reason for seeking outpatient care. It also leads to absenteeism, decreased productivity and other prejudices (Shemshaki et al., 2013; Imamura et al., 2016a; Imamura et al. 2016b; Imamura et al. 2013).

Chronic nonspecific low back pain (LBP) is defined as pain in the lumbar region with no well-defined anatomopathological diagnosis (Imamura et al., 2013; Murray et al., 2012; Hoy et al., 2010; Rached et al., 2012). Thus, an accurate assessment that considers not only biomechanical but also sensorial and autonomic factors, may provide additional information for a better understanding of this condition.

A simple way to evaluate autonomic disorders is thermography

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(Zaproudina et al., 2006). This modern technique was developed in the 1950's for military use (Jiang et al., 2005). The first report of its medical application confirmed that the skin temperature of breasts with tumors was higher than that the one in the contralateral normal tissue (Jiang et al., 2005; Szentkuti et al., 2011). Since then, this completely painless, non-invasive and fast technique has been employed, as it has no contraindications or side effects, and constitutes in a significant marker of physiological dysfunctions, as skin surface temperature is an indicator of health condition (Jiang et al., 2005; Szentkuti et al., 2011; Nahm, 2013). Another example is the mapping of ischemic tissue areas or the detection of tissues with increased temperature (Jiang et al., 2005; Szentkuti et al., 2011; Jones and Plassmann, 2002).

A study using thermographic liquid crystals (Rubal et al., 1982) verified that thermography can be useful to objectively document affected soft tissues in patients with LBP. A previous study (Zaproudina et al., 2006) reinforces that the measurement of cutaneous temperature can be useful as an adjuvant physiological test in the evaluation and documentation of autonomic dysfunction in patients with chronic low back pain.

It has already been documented that temperature in the paravertebral region of individuals with acute low back pain is higher in the affected side (Roy et al., 2010). However, authors who compared paravertebral temperature of individuals with and without chronic low back pain observed that those who presented the condition had lower temperature in relation to asymptomatic individuals (Roy et al., 2013). The unexpected result prompted them to argue that, in addition to the small sample, further investigations were certainly needed to provide a better understanding of inflammatory processes and the regulation of surface temperature (Roy et al., 2013).

Since thermography provides information on blood perfusion, this quantitative method may indicate alterations at the evaluated sites (Jones and Plassmann, 2002). Thereby, thermography may be useful for investigating circulation and superficial temperature in pathological conditions with musculoskeletal repercussions such as LBP, which may affect peripheral blood flow (Kobrossi, 1984).

Another type of assessment that has been used in patients with LBP is algometry (Shemshaki et al., 2013; Imamura et al., 2016a; Imamura et al. 2016b; Imamura et al. 2013). Algometry objectively evaluates pressure pain tolerance thresholds (PPT), and studies have recommended its use in the evaluation of patients with LBP, as well as in the establishment of relationships between functionality and pain (Shemshaki et al., 2013; Imamura et al., 2016a; Imamura et al. 2016b; Imamura et al. 2013).

Individuals with LBP present lower values of PPT when compared with healthy individuals (Shemshaki et al., 2013), and PPT seems to be associated with pain and functionality (Imamura et al., 2013).

As body temperature is also an indicative of health condition, and due to the complexity of the normal temperature pattern and possible anatomic variations, combining thermography and sensory examinations may be valuable for a good clinical judgment (Uematsu, 1985). We hypothesize that there is an association between body temperature and PPT in individuals with LBP. Therefore, the aim of this study was to verify and compare the association between lumbar superficial temperature and pressure pain tolerance thresholds in individuals with LBP and healthy controls.

2. Methods

This was an observational cross-sectional study approved by the local Research Ethics Committee, protocol number 2.066.482.

2.1. Volunteers

Sample size was determined as to seek a difference of at least one degree in temperature between groups in the lumbar region, with the same standard deviation, according to the literature (Chapman and Syrjala, 1990; Ring and Ammer, 2012). With an alpha of 0.05 and power of 80%, sample size was 16 patients for each group. As this was a transversal study, taking advantage of the availability of participants, 38 patients with LBP and 19 healthy controls were included in the study.

Participants were recruited at the University Clinic of a private University in the city of Sao Paulo (Brazil), in February 2018, through a verbal invitation directed to those who met inclusion and exclusion criteria.

2.1.1. Inclusion criteria

Volunteers should be able to refer to the evaluation site independently and sign an informed written consent to participate in the research. In addition, they should have preserved cognitive ability, diagnosis of chronic nonspecific low back pain, and pain intensity at the moment of the evaluation $\geq$4 cm in the visual analogue scale (VAS) (Chapman and Syrjala, 1990), with duration $\geq$12 weeks.

2.1.2. Exclusion criteria

Patients with tumors, fever due to viral or bacterial infection, those who had used coffee or tobacco in the previous 24 h, and those with active systemic autoimmune diseases (such as Rheumatoid Arthritis, Systemic Lupus Erythematosus, Systemic Sclerosis, Sjögren's Syndrome, Antiphospholipid Antibody Syndrome, Polymyositis or Dermatomyositis) were excluded from the study.

Healthy individuals meeting the same criteria were also invited to participate in the study. Only those who indicated 0 in VAS at the moment of the evaluation (Chapman and Syrjala, 1990) were included in this group.

2.2. Method

All assessments took place at the Exercise Physiology Laboratory, at the University Clinic where the study was conducted. Volunteers underwent an initial evaluation to collect general data: age, gender, weight, height, time of clinical condition (for the LBP group only) and pain intensity assessed by VAS (Chapman and Syrjala, 1990).

Superficial temperature of the lumbar region was evaluated by one experienced blinded evaluator. The temperature of the room where the evaluations occurred was 21.2 ± 2.2 °C, and the mean air humidity was 45.3 ± 13.2%. The room had its windows and curtains closed, preventing the entrance of external lights, humidity and air circulation. As the conditions for this type of examination must be standardized (Ring and Ammer, 2012; Fernández-Cuevas et al., 2015; Marins et al., 2014), the following additional procedures were adopted:

- before the exam (about 2 h), participants could not take hot baths or showers, use lotions or powder, or perform vigorous exercises;
- volunteers fasted for 2 h before the exam, and were instructed not to take in stimulants, beverages containing alcohol or caffeine, not to use nasal decongestants and not to smoke.

Once all requirements were met, volunteers were asked to keep their lumbar spine areas exposed to room temperature for a period of 15 min to achieve thermal equilibrium with the temperature of the examination room.

Each participant remained standing and local temperature was evaluated by an infrared sensor (IRtek® model Ti50+, Joondalup, Western Australia, Australia). Volunteers were individually positioned at 1.5 m from the sensor. The mean temperature of the evaluated sites was analyzed. These sites were: paravertebral muscles in the right and left lumbar region at the level of the L4-L5 vertebral segment, identified at the height of the iliac crest and the supra-spinal ligament at L4-L5 (Fig. 1). These sites have already been evaluated by a previous study using algometry (Alfieri and Bernardo, 2017).

Algometry was conducted by one experienced blinded evaluator with a J Tech algometer (Salt Lake City, UT, USA). The device contains at its extremity a rubber of 1 cm^2 in diameter, capable of recording, through an electronic device, the pressure applied to a surface. Pressure was applied at a constant speed of 1lb/sec up to the level at which the participant reported pain or discomfort. The result was expressed in lb/cm^2. During the evaluation, volunteers were instructed to say "stop" as soon as the feeling of pressure was no longer unpleasant, but painful. The test was discontinued as soon as the onset of pain was indicated, and the final amount of pressure applied was recorded. The evaluated sites were the same as in the thermographic evaluation, but for this assessment each individual laid in prone position (supraspinous ligament at L4-L5) and lateral decubitus (right and left paravertebral muscles).

2.3. Data analysis

Data analysis was carried out in SPSS statistical package for Windows v.22. Kolmogorov-Smirnov and Shapiro Wilk tests rejected the normal distribution of the data, so comparison between groups was made by Mann-Whitney test, and correlations by Spearman's ρ test. Correlations were interpreted according to the following criteria: $0,0 < r < 0.2$: very weak, $0.2 < r < 0.4$: weak, $0.4 < r < 0.6$: moderate, $0.6 < r < 0.8$: strong, $0.8 < r \leq 1.0$: very strong. In all cases, the descriptive level α was set at 5%.

3. Results

The sample consisted of 38 patients LBP and 19 healthy controls (CG). Groups were homogeneous regarding age, sex, weight and height. The duration of pain and its intensity when evaluated by VAS in LBP individuals are shown in Table 1.

Regarding algometry, patients with LBP had a significantly lower pain tolerance at all sites evaluated when compared to CG participants (Table 2).

Thermography data revealed significantly higher temperatures in patients when compared to controls at the three sites evaluated, as shown in Table 3.

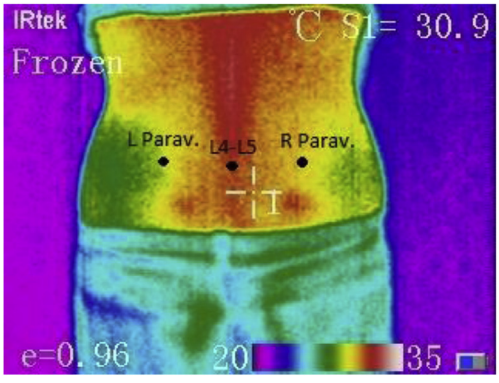

Fig. 1. Sites evaluated by algometry and thermography.

Table 1
Demographic data.

	LBP	CG	p
Sex (% female)	66.3	47.4	0,82
Age (years)	52.6 ± 12.8	47.8 ± 13.9	0.13
Weight (kg)	73.1 ± 14.4	69.1 ± 9.5	0.37
Height (cm)	159.1 ± 9.5	164.0 ± 8.8	0.07
Duration of pain (months)	117.9 ± 103.9	–	–
VAS	7.4 ± 1.8	–	–

LBP: low back pain group; CG: control group; VAS: visual analogue scale.
Data are expressed as means ± standard deviations.

Table 2
Comparison of pressure pain thresholds (algometry) between groups.

	LBP	CG	p
Paravertebral R (lb)	8.3 ± 3.7	13.1 ± 5.5	0.003
Paravertebral L (lb)	8.1 ± 3.1	12.9 ± 5.4	0.001
L4-L5 (lb)	8.3 ± 3.6	12.8 ± 5.6	0.003

LBP: low back pain group; CG: control group; R: right; L: left.
Data are expressed as means ± standard deviations.

Table 3
Comparison of superficial temperature between groups.

	LBP	CG	p
Paravertebral R (°C)	32.0 ± 1.5	29.7 ± 1.8	<0.001
Paravertebral L (°C)	31.9 ± 1.1	29.5 ± 2.2	<0.001
L4-L5 (°C)	32.8 ± 1.1	29.9 ± 2.1	<0.001

LBP: low back pain group; CG: control group; R: right; L: left.
Data are expressed as means ± standard deviations.

Among LBP patients, pain perception (VAS) correlated weakly and inversely with PPT (right paravertebral), and moderately with the temperature of all sites evaluated (Table 4). No association could not be established among CG participants because their pain perception was equal to zero.

There was a weak to moderate inverse association between PPT and temperature of the areas evaluated in LBP patients. These associations were not significant in GC (Table 5).

4. Discussion

The aim of this study was to verify and compare the association between lumbar superficial temperature and pressure pain tolerance thresholds in individuals with LBP and healthy controls. As expected, individuals with LBP had lower PPT values than healthy individuals. These data corroborate a study by Imamura et al. (2013) where the L4-L5 ligament was evaluated, among other regions, and authors also found lower PPT values in individuals with LBP when compared to controls.

Table 4
Correlations between pain perception, pressure pain tolerance and superficial temperature.

	LBP	
	r	p
VAS x PPT - R Paravertebral	−0.31	0.05
VAS x PPT - L Paravertebral	−0.19	0.25
VAS x PPT - L4-L5	−0.19	0.26
VAS x Temperature - R Paravertebral	0.51	0.001
VAS x Temperature - L Paravertebral	0.55	<0.001
VAS x Temperature - L4-L5	0.59	<0.001

LBP: low back pain group; VAS: visual analogue scale; PPT: pressure pain threshold; R: right; L: left.

Table 5
Correlations between pressure pain thresholds and superficial temperature.

	LBP		CG	
	r	p	r	p
PPT x Temperature - R Paravertebral	−0.49	0.002	−0.33	0.16
PPT x Temperature - L Paravertebral	−0.29	0.07	−0.43	0.06
PPT x Temperature - L4-L5	−0.36	0.02	−0.42	0.07

LBP: low back pain group; CG: control group; PPT: pressure pain threshold; R: right; L: left.

Other studies have also shown that individuals with LBP have lower PPT values than healthy individuals (Staud, 2011; Farasyn and Meeusen, 2005; Özdolap et al., 2014). Thus, it is believed that these individuals develop central sensitization, which would explain the perpetuation of chronic pain in the lumbar region (Imamura et al., 2016c).

The results of the present study show that pain perception, assessed by VAS, was weakly and inversely associated with PPT in the right paravertebral site of LBP patients. The observed correlation ($r = -0.31$) was similar to the one found by Imamura et al. (2016c) between VAS and PPT in the medial region (L4-L5) ($r = -0.32$).

The moderate association between VAS and temperature in the three evaluated sites is an interesting finding. It reveals that the higher the local temperature, the higher the pain perception. When it comes to temperature, the difference of more than 2° in individuals with LBP in relation to controls at the three sites evaluated shows that patients probably have higher local blood flow, namely, higher perfusion in these areas (Jones and Plassmann, 2002). Thermography was shown to be useful for evaluating lumbar perfusion disorders in individuals with LBP.

Giesecke et al. (2004) suggest that there is an increase in regional cerebral blood flow associated with the application of painful stimuli in patients with chronic low back pain. This variable was not evaluated in the present study; however, in the same line of reasoning, there was an association between pain assessed by VAS or algometry (PPT) and superficial temperature evaluated by thermography, which evaluates local blood flow. Significant associations between algometry and thermography were found in two of the three sites evaluated, objectively corroborating the fact that pain is related to an increased superficial circulation characteristic of this type of condition.

Blood flow is related to the autonomic nervous system, which controls vasoconstriction and vasodilation of the capillaries for the maintenance of body homeostasis. Therefore, the relationship between superficial temperature and blood flow is sufficient to consider it as a factor that influences the thermal image (Fernández-Cuevas et al., 2015), thus confirming the increase in blood flow in chronic LBP.

It is still necessary to highlight that in the present study temperature assessed by thermography was associated to pain perception. Data visualized in thermograms revealed that this is a promising way of evaluation to objectively analyze the clinical scenario of patients with LBP. Objective measurements in conditions with subjective symptoms, such as LBP, deserve further investigations.

To the best of our knowledge, no study so far has found association between PPT and superficial temperature. The results herein, revealing a weak to moderate correlation in LBP patients, though significant (indicating that the higher the temperature, the higher the pain), are innovative and deserve more detailing in future studies, since individuals with LBP probably present continuous inflammation and central sensitization, which perpetuates, respectively, local blood flow and the enhancement of painful stimulus.

Further studies should be conducted evaluating, for example, muscle strength, function, and inflammatory markers in patients with LBP. Investigation of possible associations between superficial temperature and algometry at distant sites from the lumbar region could further elucidate the presence of central sensitization in these patients. Clinical studies are desirable to check for changes in temperature following rehabilitation procedures, and whether these are related to a decrease in pain.

4.1. Limitations

The cross-sectional nature of this study prevents clear prediction of a cause-effect relationship. However, our data indicates that thermography is an interesting method for assessing LBP patients. Despite this limitation, methods of objective pain quantification were employed in this study. Digital algometry is the gold standard method for evaluation of PPT (Egloff et al., 2011).

5. Conclusion

Individuals with low back pain have lower pain tolerance and higher superficial temperature in the lumbar region when compared to healthy individuals. The observed associations show that the higher the pain perception, the lower the pain tolerance and the higher the superficial temperature of the lumbar region. Also, the higher the temperature, the lower the tolerance to pain.

5.1. Clinical relevance

- Thermography is a fast and low-cost method of screening for skeletal muscle disorders.
- Algometry and thermography provide objective measures of subjective symptoms.
- These assessments may contribute to the clinical follow-up of the patient with low back pain.

Conflicts of interest

Authors declare to have no conflict of interest related to this research.

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