PARASPINAL CUTANEOUS TEMPERATURE MODIFICATION AFTER SPINAL MANIPULATION AT L5

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ABSTRACT

Objective: The purpose of this study was to investigate local paraspinal cutaneous temperature (CT) modifications after spinal manipulative therapy at L5.

Methods: Twenty subjects with acute low back symptoms were randomly assigned to either a treatment or a sham group (n = 10 per group). Subjects underwent an 8-minute acclimatizing period. Temperature was measured bilaterally with infrared cameras at the L5 level. In the treatment group, a traditional chiropractic manipulation (lumbar roll technique with a pisiform contact on the ipsilateral mamillary of L5) was delivered, whereas with the sham group, the same technique was used, but no thrust was applied. Cutaneous temperature control measurements were taken 2 minutes before (t−2) and immediately after the intervention (t0) and at 1, 3, 5, and 10 minutes postintervention (t1, t3, t5, and t10, respectively).

Results: At t0, CT in the treatment group on the treatment side (ipsilateral side) warmed up by 0.2°F, whereas in the sham group, there were no significant temperature modifications on either side. At t3 relative to t0, CT in the treatment group on the treatment side warmed by approximately 0.6°F, whereas the contralateral side (nontreatment side) cooled. In the treatment group, significant differences were noted between sides (F = 13.36, P = .002, P = .932) and sides × times (F = 2.97, P = .016, P = .838).

Conclusion: The effects of a lumbar spine manipulation appear noticeable by changes in paraspinal CT measurements at the level of L5. However, the meaning and mechanisms of CT modifications at L5 are still being investigated. (J Manipulative Physiol Ther 2010;33:308-314)

Key Indexing Terms: Manipulation, Spinal; Thermography; Chiropractic

The application of thermometry principles has been proposed as potentially useful in chiropractic medicine.1 It has recently been shown that paraspinal cutaneous temperature (CT) can be reliably measured clinically by thermometry under controlled conditions.2-4 Recently, a study, using a handheld thermographic scanner, evaluated the interexaminer and intraexaminer reliability; and it was found to be very high.2 In another study,3 15 subjects were evaluated with 30 spot-shot repeated measures per day of recording (15 in the lumbar area at L5 and 15 in the cervical area at C5) on 5 different occasions and at different times of day, for a total of 2250 recordings. The total of these recordings was used to establish infrared camera CT validity and reliability; there were strong significant correlations between skin thermistors and infrared camera recordings at L5 that were established. Optimal period for CT measurement has also been a subject of interest. Owens et al2 have shown that a 16-minute acclimation period is necessary for the purpose of pattern analysis of paraspinal CT. In another study conducted by Roy et al,4 2 stabilization periods were identified as acceptable for adequate CT recordings, one occurring between minute 8 and 16 and a second between minute 30 and 45. Roy et al4 proposed that, for a clinical setting, the 8- to 16-minute stabilization period is more practical, but a controlled environment (stable room temperature, ∼22°C ± 1.0°C) is necessary to obtain valid and reliable recordings.

Several authors have been proposed that thermometry based on paraspinal differences at the same segmental level...
may be indicative of somatospinal inconsistencies requiring a chiropractic adjustment.  

Several studies using CT thermography recordings have shown that there are temperature gradients along the length of the spine. However, to the best of our knowledge, there is one scientific study done with humans that has evaluated the effect of a spinal manipulative therapy on paraspinal CT. The study measured the effect of a manually assisted mechanical force on lumbar paraspinal CT using an instrument to limit the possible heat transfer from the clinician’s hand unto the patient CT. Cutaneous temperature was modified after the intervention, but the mechanisms involved at this time are entirely speculative. In addition, a study by Harris and Wagnon has shown that a chiropractic adjustment can modify fingertip CT depending on the specific region of spine adjustment (C1-C7 and/or L4-L5). Thus, it appears that spinal manipulations can alter CT; however, the effects of these spinal manipulations are still unknown on lumbar paraspinal CT.

To this day, emerging technologies are being explored, such as visible and infrared light, microwaves, terahertz rays, and intrinsic and applied electric and magnetic fields. Furthermore, the utilization of handheld thermometric equipment is well advertised; and its use is empirical at best. Despite this and as mentioned earlier, there is still a lack of concrete objective data in the scientific literature on changes to paraspinal CT procured by spinal manipulative therapy.

Nevertheless and as stated by Plaugher, continued investigation is needed in the area of thermographic research. It has been proposed that future research should focus on thermography as a noninvasive outcome measure and improved interpreter reliability. Thus, based on the above succinct review of CT measurements in the field of chiropractic practice, the goal of the current study was to investigate the local CT modifications after spinal manipulative therapy at L5. We hypothesized that spinal manipulation at the level of L5 would modify the paraspinal CT.

**METHODS**

**Participants**

The required number of subjects was calculated from a previous study. The following equation was used, from Cohen, based on the statistic \( d \), where:

\[
x_1 = \text{the average measurements in group 1} \\
x_2 = \text{the average measurements in group 2} \\
SD_1 = \text{the standard deviation in group 1} \\
SD_2 = \text{the standard deviation in group 2} \\
d = \frac{(x_1 - x_2)/\sqrt{(SD_1^2 + SD_2^2)/2}}.
\]

The 2 averages used were 93.35°F ± 2.06°F and 91.54°F ± 1.75°F. The difference of the averages gave 1.81, and both standard deviations were used in the above formula to calculate \( d \).

\[
d = \frac{1.81}{1.91} = 0.95
\]

Thus, the calculated Cohen’s \( d \) was determined as 0.95. In a validity and reliability study with repeated measures, the \( R \) value (was also calculated but not published) was 0.81. This allowed us to calculate \( d' \) using the following formula:

\[
d' = \frac{d}{\sqrt{1-R}}
\]

The resulting \( d' = 2.17 \).

Using Cohen’s formula:

\[
n = \frac{n_{d=0.01}}{100 \times d'^{2} + C}
\]

Where: \( n \) = the number of subjects required, \( n_{d=0.01} \) = the number of subjects for \( d' = 0.1 \), which according to Cohen’s table is 1571 for 80% power (0.80) or 2102 for 90% power (0.90), and \( C = 1 \) for an \( \alpha = 0.05 \).

We obtained the resulting number of estimated subjects required for an \( n \) at power of 0.80 = 4 and for an \( n \) at a power of 0.90 = 6. In summary, Cohen’s table was used, with \( P = 0.05 \) at a power of 90%; and it was determined that a minimum of 6 subjects per group were necessary. Thus, we elected to have 10 subjects per group. Twenty subjects in all were recruited between the period of February 2006 and May 2006, 12 women and 8 men. The subjects presented with an acute low back condition requiring chiropractic care. Anthropometric characteristics of the subjects are shown in Table 1. Subjects were randomly divided into 2 groups (\( n = 10 \) per group), a treatment group and a sham group. Ethics approval was obtained from the institutional review board of the Université du Québec à Montréal. Informed written consent was obtained from all subjects.

The inclusion criteria were that all subjects be free of any underlying pathologic conditions (acute or chronic diseases, cold, and/or any thermogenic disease) that could affect their CT outside of the condition requiring chiropractic care. The subjects were instructed not to drink any coffee or any other beverages containing caffeine (eg, caffeinated soft drinks, tea) and to abstain from smoking or chewing tobacco at least 2 hours before the recording session. In addition, female subjects were asked to present at a later time if they were having their menses. On the day of recording, subjects

<table>
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<th>Table 1. Anthropometric measurements by groups</th>
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<td>Age (y)</td>
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Values are mean ± SD. Differentials are absolute values. NS, nonsignificant.
were asked if they had complied with the inclusion criteria; if not, they were asked to present at a later time.

**Experimental Conditions**

The assessor (person setting the equipment and doing the recordings) was blinded to the allocation of the patients to different groups and did not interact with the patients or the clinician. The person administering the adjustment (clinician) was not blinded to the group assignment.

Two independent variables composed the research design: groups (treatment and sham) and sides (manipulation side identified as ipsilateral and nonmanipulation side identified as contralateral). Subjects of both groups underwent orthopedic, chiropractic, and neurologic evaluation; radiographs; and history before the day of recording by the clinician, including motion palpation, static palpation, and range of motion. Subsequently, on the day of recording, after the acclimation period and the initial CT measurement, the subjects received a spinal manipulation at L5 in the side posture. The technique used was a traditional lumbar roll, with a pisiform contact on the ipsilateral mamillary of L5. The site of interest was defined at the level of the lumbar spine, left or right L5. The side of contact was always considered the ipsilateral side. This specific level was chosen because, anecdotally, it is the articulation that is most often adjusted in cases of low back pain. The technique of spinal manipulation was the diversified chiropractic technique of the basic lumbar roll.

The sham-group subjects were administered a 5-second pressure with the clinician’s hand without the thrust associated with a spinal manipulation. Sham-group subjects also lay in side posture for the sham treatment. A sham group was included in this study to distinguish the effect of a simple pressure from that of a spinal manipulation on CT. The sham group was told that they had received no manipulation only after the recording session had been completed.

**Measurements**

The CT measurements were obtained with infrared cameras. All temperatures were recorded in degrees Fahrenheit. The infrared cameras were calibrated on-site using the manufacturer’s recommendations. The cameras used were not the rolling-type cameras but the handheld square box-like cameras. To introduce a constant half-inch measurement, the subjects received a spinal manipulation at L5 in the side posture; it took less than 30 seconds for the subjects to return to the prone position from the side posture. Cutaneous temperature was measured at the following 6 specific time points: before the spinal manipulation ($t_{-2}$) that served as a control period; at the time immediately after the spinal manipulation ($t_0$); and 1, 3, 5, and 10 minutes after the spinal manipulation ($t_1$, $t_3$, $t_5$, and $t_{10}$, respectively).

Infrared cameras recorded directly into the Subluxation Station Insight 7000 (Chiropractic Leadership Alliance, Mahwah, NJ). All data were collected at a room temperature of 21.95°C ± 1.0°C (data not shown).

**Experimental Procedures**

When the subjects arrived for a recording session, the subjects were greeted, and then completed and signed all the required documentation. The randomization of subjects was performed by having each subject pick a number from an envelope. Each number was discarded after it had been picked by a subject. The participants were aware of the intervention to come. They proceeded to the treatment room and donned a cotton gown that had an opened slit in the back. The subject then proceeded to lay prone on a chiropractic table. The head was placed in a neutral position by adjusting the headrest portion of the table. The patient rested on a chiropractic table for 8 minutes. The initial recording ($t_{-2}$) was then executed. After the initial recording, the doctor of chiropractic began the adjustment for the treatment group and the pressure for the sham group, of the preevaluated subjects, for an L5 spinal dysfunction. Afterward, the spinal recording session continued. The total recording session lasted 10 minutes. After the last recording, the subjects were instructed to get up and get dressed, and were thanked for their participation in the study. There was no protocol deviation. There were no adverse events reported for all subjects throughout the study.

**Statistical Analysis**

Descriptive statistics (mean ± SD) were computed for all conditions. Afterward, a factorial groups × sides × time analysis of variance (ANOVA) model with repeated measures was used to compare all main effects and interactions (SPSS 15.0; SPSS Inc, Chicago, IL). When the recording was done. That period of settling varied between 5 and 10 seconds. When the temperature settled on the screen, the technician would then depress the recording pedal. The handheld units were held on the sides over the wooden sticks to avoid heat transfer from the technician and affect the recordings. The target area was identified by the clinicians with 2 felt pen markings 4 in lateral to the spinous process of L5, outside the recording area of the lenses. The recordings were all done in the prone position, and the treatment was in the side posture; it took less than 30 seconds for the subjects to return to the prone position from the side posture. Cutaneous temperature was measured at

level of statistical significance established at $\alpha = 0.05$ was obtained, Tukey honestly significant difference post hoc tests were performed to determine specific significant differences. The results are provided by giving the $F$ ratio along with the obtained levels of type I error ($p$) and observed power ($P$). Subsequent to our initial analysis, we performed a within-subject ANOVA for each group.

**RESULTS**

Table 1 presents the anthropometric representation of both groups. There were significant differences in age ($P = .04$), weight ($P = .0004$), and body mass index (BMI) ($P = .002$) between the groups; but there were no significant differences in height.

Table 2 presents ANOVA results from both groups. There were statistically significant differences (shown in bold characters) between CT taken on different sides ($F_{1,18} = 13.363, P = .002$) and times ($F_{5,90} = 3.238, P = .01, P = .872$). There was a significant interaction between sides $\times$ time ($F_{5,90} = 2.970, P = .016, P = .838$). There were no significant differences between groups.

Tables 3 and 4, respectively, illustrate the results of the ANOVA for the treatment and sham groups. Only the treatment group had significant side and side $\times$ time differences. Figure 1 presents the initial measurement at $t_{-2}$ for each group and side. The side ipsilateral to the spinal manipulation, or subluxated side, was warmer than the nonsubluxated side for both groups; but the difference was not statistically significant. The sides are identified as ipsilateral and contralateral in relation to the side of subluxation. The sham group is cooler than the treatment group. The average CT at L5 was 92.67°F ± 1.60°F for the treatment group and 91.37°F ± 1.42°F for the sham group (data not shown) and was not statistically different ($F_{1,8} = 1.493, P = .238$). Figure 1 shows CT (in degrees Fahrenheit) measurements over time ($t_{-2}, t_{0}, t_{1}, t_{3}, t_{5}$, and $t_{10}$) after the 8-minute acclimation period. Figure 1 shows temperatures of the ipsilateral (manipulation side) and contralateral (nonmanipulation side) sides at L5 for both the treatment (Fig 1A) and sham (Fig 1B) groups. In the treatment group, the treated side was cooler by 0.46°F immediately after the adjustment ($t_{1}$) and later warmed by 0.49°F at the $t_{10}$ mark in relation to $t_{-2}$ and 0.95°F in relation to $t_{1}$, whereas the contralateral side cooled down for the entire recording period and at $t_{10}$ was 0.17°F cooler in relation to $t_{-2}$. Note that the asterisks represent significant differences for the time slots of sides $\times$ times interactions (Tables 2 and 3). In the sham group, both sides remained parallel to each other (Fig 1B). There was an initial warming from $t_{-2}$ to $t_{0}$, which culminated in a total warming effect at $t_{10}$ of 0.75°F and 0.76°F, respectively, for the ipsilateral and contralateral side. There were no significant differences for sides $\times$ times interactions.

Figure 2 shows CT measurements expressed as differential of temperature, in relation to the initial measurement at $t_{-2}$ over time ($t_{-2}, t_{0}, t_{1}, t_{3}, t_{5}$, and $t_{10}$) after the 8-minute acclimation period. Figure 2A and B represent treatment and sham groups, respectively. In the treatment group (Fig 2A), there was a separation in the 2 curves, whereas in the sham group, the curves were almost superimposed. In the treatment group, the CT on the ipsilateral side was significantly greater at all iso–time points, except for $t_{-2}$ and $t_{1}$, when compared with the contralateral side.

**DISCUSSION**

The main finding was a significant change in CT in the treatment group on the ipsilateral side (treatment side) compared with the contralateral side (nontreatment side)
This was in sharp contrast to the sham group, which showed similar ipsilateral and contralateral CT responses after a sham intervention (Fig 1B and Table 4). It was also observed that a warming of CT occurred in both the treatment and sham groups immediately after the intervention ($t_\sim 2$ to $t_0$). One possible explanation is that the initial posttreatment rise in CT was probably due to heat transfer caused by the chiropractor’s hand during the intervention. This point will be discussed later.

**Treatment Group**

Figure 1A shows the results obtained from the spinal manipulation performed in a side posture position that appears to produce a warming effect on the ipsilateral side. The asterisks in the time slots correspond to the significant sides × times interactions for the treatment group only. Filled symbols indicate treatment side CT measurements (ipsilateral side); empty symbols indicate opposite to treatment side CT measurements (contralateral side).
(treatment/adjustment side) and a cooling effect on the contralateral side. This observation represents a multiphasic CT response described as follows. A drop in CT was observed on the ipsilateral side 1 minute \((t_1)\) after the intervention followed by a CT rise until \(t_3\). At \(t_5\), a second drop in CT was observed and again was followed by a continuous CT rise until \(t_{10}\). This was typical on the ipsilateral side for every subject in the treatment group. On the other hand, the treatment group contralateral side had an opposite monophasic reaction that showed a constant CT decay until \(t_{10}\) when compared with the ipsilateral side. A possible explanation for the multiphasic CT reaction of the ipsilateral side is at least 2-fold. The first CT rise \((t_1 \text{ to } t_3)\) is probably a vascular reaction caused by the chiropractor’s contact on the spine that compresses local tissues and causes a reactive/ischemic hyperemia upon contact release. A neurologic sympathetic vascular reaction is also possible, and there are probable links of both blood pressure and heart rate variability modulations that can be linked to CT modifications.\(^8,15\) The second CT rise \((t_5 \text{ to } t_{10})\) is most probably associated to a response release of cytokines and other pro- and anti-inflammatory mediators.\(^{16}\) The inflammatory response of the tissue is of great value, isolating the damaged area, mobilizing effector cells and molecules to the site, and in the later stages promoting healing.\(^16\) Thus, the multiphasic warming \((t_3, t_5, t_{10})\) measured by CT could be regulated by either a neurologic supraspinal control, a physiologic cellular reaction from the cutaneous or deep tissue blood vessels, or the immunologic systems.

For clinicians, the warming measured by thermometry can reveal valuable information about tissue response after a manipulation. Briefly, the effect of the adjustment initially creates a reactive circulation (reactive/ischemic hyperemia) that may be a simple blood perfusion after applied pressure on the skin. The tendency of the adjusted area to continue warming is likely a positive inflammatory response reflex removing residues from the injured area via increased blood flow. The CT changes might have to do with different factors, including axonal reflexes, the release of a chronic muscle spasm, as well as a normal tissue response to mechanical stimulus.\(^8,16\)

Sham Group

Figure 1B shows that both the ipsilateral and the contralateral sides have similar CT for all iso-time points. Both sides warmed by similar amounts after the sham treatment followed by a drop and rise in CT \((t_1 \text{ to } t_3)\), typical of a biphasic response. The ipsilateral side appears to be warmer, but this difference is not significant. Nonetheless, this could somehow be considered normalization (ie, trending to values similar to the treatment group) after the application of the chiropractor’s hand at the site of the adjustment. However, the contralateral side was not touched and also showed a normalization (warming) effect. Physiologically, as discussed in the treatment group section, there is a blanching/reddening effect. When tissues are compressed mechanically, there is a temporary lack of blood supply. When this mechanical deformation of the tissue is sustained, there is often a rebound perfusion effect to resupply the area (reactive/ischemic hyperemia). It could also be a response from sensory receptors of the skin producing an axonal reflex associated with antidromic reaction from the cutaneous nerves.\(^{17,18}\) Thus, the same mechanisms as discussed in the treatment group section could be involved, except for the fact that the CT response in the sham group is biphasic in contrast to the multiphasic response in the treatment group. Hence, there may be a lack of physiologic cellular reactions (deep tissue blood vessels or immunologic reactions) not brought about by the mock intervention in the sham group that characterized the latter CT response in the treatment group.

Pain-Free Patients vs Patients in Pain

Comparing the present results, patients with an acute low back condition, with our previously published work\(^8\) where we studied patients without pain, we observed an opposite trend on the initial CT measurement. In the 2008 study, the ipsilateral side (subluxated side) was contacted by an instrument (colder); and in the present study, the contact was by hand (warmer), which is perhaps the reason for opposite CT responses at time 0 immediately after the intervention. This means, beyond any doubt, that a certain period is needed before making a postintervention evaluation, possibly 3 to 5 minutes.

As well, in the present study, CT was colder on the subluxation (ipsilateral) side in pain-free patients with low back conditions necessitating support care. This raises the question of whether it is possible that CT measurement may be valuable in the diagnosis of pain-free as well as painful conditions. Cutaneous temperature monitoring throughout the entire treatment course for patients initially in pain to the later part of the treatment when patients are pain free, but still subluxated, may indicate the possible need for care without the presence of pain while providing the diagnostic clues to pursue treatment. This is an interesting point of view; but firstly, physiologic mechanisms involved in CT changes must be identified. At the moment, more research is needed to observe changes over time associated with clinical correlations.

Limitations

This type of speculation, as discussed above, is an observation that cutaneous thermometry lacks sufficient research to understand all the underlying principles. In addition, because little is known about normal values for pain-free subjects, it cannot be assumed at the moment that rewarming is neither beneficial nor detrimental. As well, a previously unmentioned objective in this study was an attempt...
to caution on the overuse, underuse, or misuse of thermometry. Currently, research is being pursued to establish various CT parameters, including a paraspinal CT index that hopefully could be useful for any individual using thermometry.

There were no attempts to blind the assessor from the thermal assessment because the data were recorded directly into the computer after each measurement and the assessor needed to ensure settling of the recording before depressing the recording pedal. Only one recording was taken at each measurement or time marker. The assessor could not know the value during measurement. The risk of influencing thermal estimation was minimized to nil by ensuring outmost rigor of the measurement protocol by the assessor.

The BMI (Table 1) for the sham group was significantly greater and could have been a factor for the lower initial preintervention CT, even though, as mentioned earlier, the average preintervention CT at L5 was not significantly different between both groups (“Results” section). The sham group was also significantly older. This significance is important but perplexing because, according to Dufour and Candas, older subjects and middle-aged subjects should have a higher CT than younger individuals. Yet according to Wilson et al., a greater heat loss in older subjects could also indicate a possible cutaneous vasoconstrictor dysfunction resulting from an inability to prevent heat loss via skin that is typically associated with older subjects. Yet neither seems to apply in the present study because CT analysis suggests that both groups are not statistically different (Table 2) even though anthropometrically they are.

**CONCLUSION**

Contacting the skin with the hand with a sustained pressure produced an initial warming immediately after the contact. A spinal manipulation produced a cooling followed by a rewarming of the CT, as it was observed between $t_1$ and $t_5$. A secondary cooling at $t_5$ was followed by a rewarming at $t_{10}$. Mechanisms are still being investigated.

**Practical Applications**

- A spinal manipulation creates a warming of the paraspinal CT.
- Thermometry is still in its infancy age, and it is currently considered a technology under investigation and is different from thermography.

**FUNDING SOURCES AND POTENTIAL CONFLICTS OF INTEREST**

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