Effects of a Manually Assisted Mechanical Force on Cutaneous Temperature

Richard A. Roy, DC, MSc,[a] Jean P. Boucher, PhD,[b] and Alain S. Comtois, PhD[b]

Abstract

Objective: Digitized infrared segmental thermometry (DIST) is a tool used for measuring cutaneous temperature (CT). This project ascertains the effect of a manually assisted mechanical force producing a chiropractic adjustment in the lumbar spine after the Activator Methods Chiropractic Technique on CT during 2 different time recording periods (TRPs).

Methods: Sixty-six healthy subjects (36 women and 30 men) without acute low back conditions or symptoms were recruited. Subjects were randomly divided into 2 groups based on the length of the acclimatization period (8 or 30 minutes; TRP_8 and TRP_{30}, respectively). In turn, each recording period group was divided into 3 subgroups (n = 11 per subgroup): treatment, sham, and control subgroups. Bilateral DIST was conducted at L-4 (TRP_{30}) and L-5 (TRP_8) using infrared cameras (Subluxation Station Insight 7000; Chiropractic Leadership Alliance, Mahwah, NJ).

Results: Before treatment ($t_{-0.5}$), the TRP_8 CT was significantly different between the ipsilateral and the contralateral sides for all subgroups. At 10 minutes (t_{10}) after intervention, CT increased significantly ($P < .05$) for the treatment group but not for the sham and control groups. In contrast, there were no significant differences in the TRP_{30} CT before treatment between the ipsilateral and the contralateral sides; but at t_{10}, CT was significantly ($P < .05$) greater for all 3 subgroups compared with preintervention CT.

Conclusion: Contacting the skin with the instrument with (treatment group TRP_{30}) or without (sham group TRP_{30}) a thrust with a sustained pressure stronger than the loading principle taught in the Activator Methods Chiropractic Technique protocol or a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument produced a CT cooling immediately after the adjustment. Furthermore, we observed that when contacting the skin with the instrument with a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument, it produced a secondary cooling at t_5 followed by a rewarming at t_{10}. Finally, contacting the skin with the instrument without a thrust and respecting the standard loading principle (sham TRP_8) of the instrument did not produce a CT change. (J Manipulative Physiol Ther 2008;31:230-236)

Key Indexing Terms: *Manipulation; Chiropractic; Thermography*

Cutaneous temperature (CT) is an intrinsic part of the body temperature complex. It is a function of the body temperature and is precisely regulated by supraspinal centers and the sympathetic nervous system.[1-4] In chiropractic medicine, paraspinal CT evaluation has been in use since 1924.[4,5] Studies using thermography recordings to investigate CT have shown that there are temperature gradients along the length of the spine.[5-12] However, to our knowledge, there are no studies reporting measurements of spinal segmental CT and its relevance for chiropractic clinical application.

Recently, it has been shown that digitized infrared segmental thermometry (DIST) is valid[12] for measuring CT at the spinal level. It has also been shown that there are 2 stable time recording periods (TRPs) available to determine CT after the subjects acclimatized to the surrounding environment while resting prone on an examination table.[13] A first period of paraspinal CT stabilization occurs between 8 and 16 minutes (TRP_8), while core temperature is still adapting to its environment; and a second occurs at 30 minutes (TRP_{30}), at which time core temperature is more stable. Therefore, there are 2 periods at which paraspinal CT can be reliably measured: TRP_8 and TRP_{30}.

It has been hypothesized that temperature differences from each side of the spine at the same segmental level, as noted with CT thermometry, may be indicative of somatospinal inconsistencies requiring a chiropractic adjustment.[10,14-16] However, no specific values have been established for diagnostic purposes. Consequently, controversy still exists concerning the effects of chiropractic

[a] Private Practice, LaSalle, Québec, Canada.
[b] Professor, Department Université du Québec à Montréal, Département de Kinanthropologie, C.P. 8888, Succursale Centre-Ville, Montréal, Québec, Canada.
Submit requests for reprints to: Alain S. Comtois, PhD, Université du Québec à Montréal, Département de Kinanthropologie, C.P. 8888, Succursale Centre-Ville, Montréal, Québec, Canada H3C 3P8
(e-mail: *comtois.alain-steve@uqam.ca*).

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Table 1. *Anthropometric measurement of the subjects*

Groups	TRP_8 Treatment	TRP_8 Sham	TRP_8 Control	TRP_{30} Treatment	TRP_{30} Sham	TRP_{30} Control
Weight (kg)	77.4 ± 12.6	65.4 ± 11.8	67.4 ± 13.6	68.1 ± 11.0	69.9 ± 16.2	69.3 ± 14.8
Height (m)	1.70 ± 0.1	1.60 ± 0.1	1.70 ± 0.1	1.70 ± 0.09	1.71 ± 0.1	1.66 ± 0.05
BMI	26.7 ± 3.8	24.7 ± 5.6	24.5 ± 3.9	23.5 ± 3.0	23.6 ± 3.4	25.0 ± 5.0

Values are expressed as mean ± SD.
BMI, Body mass index.

adjustments on CT and the clinical capacity to obtain valid measurements of CT changes.

The objective of the present study was to evaluate the effect of a manually assisted mechanical force (MAMF) chiropractic lumbar adjustment on CT during 2 different TRPs (8 and 30 min). In addition, CT on each side of the segmental level was evaluated to establish statistical differences that may be useful for diagnostic purposes.

Methods

Participants

The required number of subjects was calculated using the results from a previous study.[12] Based on an effect size of 0.25°F, a type I error of 0.05, and a power of 80% and according to Cohen's table,[17] 8 subjects per group were required. We elected to have 11 subjects per group. A total of 66 healthy subjects (36 women and 30 men) were recruited between July 2004 and July 2006 from a chiropractic clinic. The inclusion criterion was that all subjects were receiving maintenance chiropractic care and were pain free. In addition, all subjects were free of any underlying conditions (acute or chronic diseases, cold, menses, and/or any thermogenic disease) that could have affected their CT. Subjects were also instructed not to drink any coffee or any other beverages containing caffeine (eg, caffeinated soft drinks, tea) and not to smoke or chew tobacco at least 2 hours before the recording session. Compliance with the instructions was verified on the recording day. All subjects had been previously examined and radiographed. All subjects had 5 lumbar vertebrae. Subjects were also preselected according to the Activator Methods Chiropractic Technique protocol (AMCT)[18] for the presence of either an L-4 or L-5 subluxation.

Anthropometric characteristics of the subjects are shown in Table 1. The research protocols for the evaluation and adjustment were approved by the Université du Québec à Montréal ethics committee. Written informed consent was obtained from all subjects. There was no need for subject follow-up.

Conditions

Four independent variables or conditions were evaluated: periods, groups, sides, and tests. There were 2 between factors, periods (TRP_8 and TRP_{30}) and groups (control, sham, and treatment), and 2 within factors, sides (ipsilateral and contralateral) and tests (t_{pre}, t_0, t_1, t_3, t_5, and t_{10}). Subjects were randomly assigned to the recording period groups: TRP_8 and TRP_{30}. Each recording period group was divided into 3 subgroups (n = 11 per subgroup): treatment, sham, and control groups. There were 6 consecutive tests or time markers: before the intervention (ie, adjustment for the treatment groups and sham procedure for the sham groups) or t_{pre} (2 minutes before for TRP_{30} or t_{-2} and 30 seconds before for TRP_8 or $t_{-0.5}$); at the time of the adjustment (t_0); and 1, 3, 5, and 10 minutes after the adjustment (t_1, t_3, t_5, and t_{10}). The randomization was done by having each subject pick a number from a closed envelop. Each number was discarded after it had been picked by a subject. The participants were blinded to the intervention. Those administering the intervention were not blinded to the group assignment.

Measurements

All temperatures were recorded in degrees Fahrenheit using infrared cameras (IRCs) calibrated on-site using the manufacturer's procedure. The recording sites for both the TRP_8 and TRP_{30} groups were defined at the level of the lumbar spine: left and right L-5 for TRP_8 and left and right L-4 for TRP_{30}. To keep consistent half-inch distance between the IRC and the skin, as recommended by the manufacturer, wooden sticks (popsicle style) were secured on each side of each IRC casing, one on the medial aspect and one on the lateral aspect. The CT was recorded by the Subluxation Station Insight 7000 (Chiropractic Leadership Alliance, Mahwah, NJ). All data were collected at room temperature in a normal clinical setting (one private clinic).

Limitations in the Thermal Measurements

There were no attempts to blind the thermal assessment because the data were recorded directly into the computer after each measurement. At each test or time marker, only 1 recording was taken. The examiner could not know the value during measurement. The risk of influencing thermal assessment was kept to a minimum by ensuring that the measurement protocol was respected by the examiner.

Interventions

Subjects of the groups received a standard AMCT evaluation; and subsequently, only the treatment groups received the usual treatment at L-4 (TRP_{30}) or L-5 (TRP_8).

The side on which the adjustment was produced was considered the ipsilateral side for our recordings, whereas the opposite side was identified as the contralateral side. The subjects in the treatment group received a single thrust from the instrument and no other treatment. The MAMF was produced using an Activator Instrument IV at the indicated level 4 for the lumbar adjustment. The attending chiropractor held an advanced proficiency rating in AMCT.[19] The treatment protocol followed the AMCT protocol for clinical application of the instrument.[18] The instrument was loaded to engage the stylus, producing minimal tissue pull; and the handle was pressed to release the hammer and produce the adjustment for the TRP_8 and TRP_{30} treatment groups.

Subjects in the sham group only received application of the instrument loaded to engage the stylus producing maximal (TRP_{30}) or minimal (TRP_8) tissue pull or pressure. The AMCT instrument was placed on the evaluated site, producing a skin fold without the thrust or adjustment. As for the treatment groups, the side on which the sham procedure was applied was considered the ipsilateral side for our recordings, whereas the side opposite the procedure was deemed the contralateral side. The sham groups were included in this study to distinguish the effects of the pressure component, without adjustment, on CT. Subjects in the sham group were told that they had received no adjustment only after the recording session had been completed.

Subjects in the control group did not receive any treatment. They were evaluated, and the side that should be treated was noted. The side that should be treated was considered the ipsilateral side for our recordings, whereas the opposite side was considered as the contralateral side. A control group was included in this study to isolate the effect of the sham procedure and the treatment.

Experimental Procedures

When the subjects arrived for a recording session, they were asked to remove their clothing except underwear. They were provided with a cotton gown that had an open slit in the back. Subjects then proceeded to lie prone on an activator chiropractic table. The chiropractor evaluated the subjects according to the AMCT protocol for the presence of a subluxation. The pelvic deficiency side and the side of the lumbar subluxation were both noted. Subjects remained in a prone position for the required acclimatization period they had been assigned, after which the recording session began. The DIST was used to measure CT on 6 consecutive tests or time markers: before the intervention (ie, adjustment for the treatment groups and sham procedure for the sham groups) or t_{pre} (2 minutes before for TRP_{30} or t_{-2} and 30 seconds before for TRP_8 or $t_{-0.5}$); at the time of the adjustment (t_0); and 1, 3, 5, and 10 minutes after the adjustment (t_1, t_3, t_5, and t_{10}). Subjects of the control groups were also tested 6 times respecting the same between-test delays. After the last recording (t_{10}), subjects were instructed to get up and get dressed and were thanked for participating in the study. Subjects in the control group proceeded to lie prone on an activator chiropractic table and did not receive any treatment. There was no protocol deviation, and there were no adverse events for all subjects throughout the study.

Table 2. *Analysis of variance table*

Sources of variance	SS	DF	MS	F	*P*	Power
Between	**2360.898**	**65**				
P	0.137	1	0.137	0.004	.952	
G	1.671	2	0.836	0.022	.978	
P × G	102.460	2	51.230	1.362	.264	
$Error_{between}$	2256.630	60	37.610			
Within	**975.362**	**726**				
S	201.616	1	201.616	**41.763**	**.000**	**0.999**
S × P	351.200	1	351.200	**72.748**	**.000**	**0.999**
S × G	7.297	2	3.648	0.756	.474	
S × P × G	18.364	2	9.182	1.902	.158	
$Errors_S$	289.658	60	4.828			
T	9.595	5	1.919	**10.548**	**.000**	**0.999**
T × P	4.080	5	0.816	**4.485**	**.001**	**0.970**
T × G	2.960	10	0.296	1.627	.098	
T × P × G	3.004	10	0.300	1.651	.092	
$Error_T$	54.583	300	0.182			
S × T	2.169	5	0.434	**4.899**	**.000**	**.981**
S × T × P	1.631	5	0.326	**3.683**	**.003**	**.928**
S × T × G	0.848	10	0.085	0.957	.481	
S × T × P × G	1.785	10	0.179	**2.016**	**.032**	**.882**
$Errors_{S \times T}$	26.572	300	0.089			
Total	**3336.260**	**791**				

SS, Sums of squares; *DF*, degrees of freedom; *MS*, mean squares; *F*, *F* ratio; *P*, probability of type I error; *P*, period; *G*, group; *S*, sides; *T*, tests.

Statistical Analysis

Those assessing the outcomes were not blinded to group assignment. First, descriptive statistics (mean ± SD) were computed for all conditions. Afterward, a 4-way, periods by groups by sides by tests, factorial analysis of variance model with repeated measures on the last 2 factors,[20] also referred to as a *split-plot factorial design*,[21] was used to compare all main effects and interactions. When the level of significant difference of $\alpha = .05$ was obtained, the Tukey honest significant difference post hoc test was performed to identify specific significant differences. The results are provided by giving the F ratio along with the obtained levels of type I error and statistical power. No other ancillary analysis was performed.

Results

Table 2 presents the results of the analysis of variance. Several significant differences were obtained and are presented in detail below. The side main effect ($F_{1,\ 60} = 41.763$, $P = .000$, power = 0.999) and the side by period interaction ($F_{1,\ 60} = 72.748$, $P = .000$, power = 0.999) yielded statistically significant differences. At the initial measurement (t_{-2}) for TRP_8, the ipsilateral side (side of the subluxation)

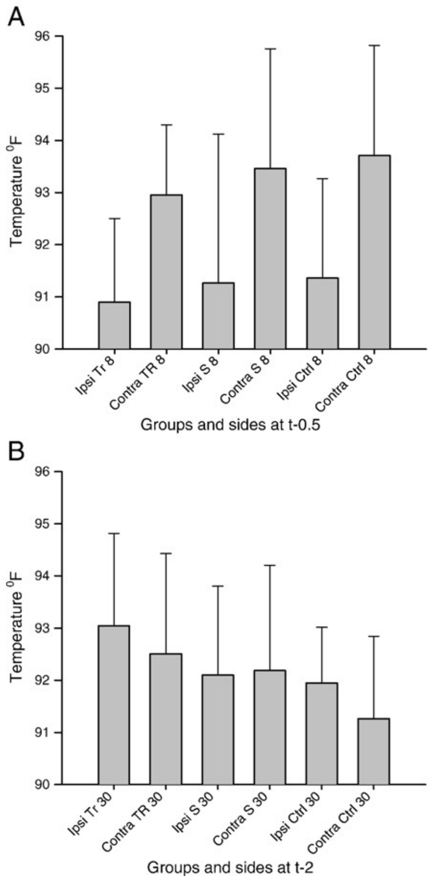

Fig 1. *A, Average CT measurements at $t_{-0.5}$ expressed in degrees Fahrenheit of the ipsilateral and the contralateral sides of all 3 groups in TRP_8. B, Average CT measurements at t_{-2} expressed in degrees Fahrenheit of the ipsilateral and the contralateral sides of all 3 groups in TRP_{30}. Bars represent the standard deviation of all measurements recorded over the total recording period.*

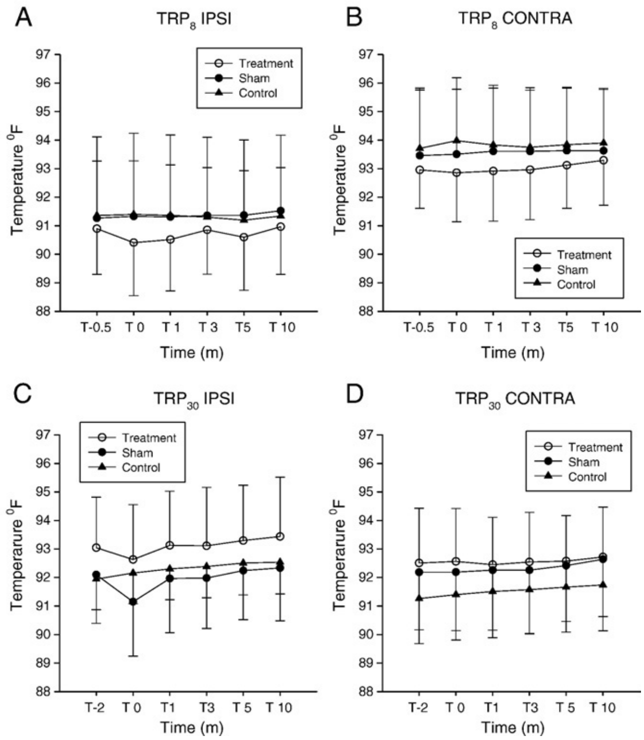

Fig 2. *Average CT measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (A) and the contralateral (B) sides of all 3 groups in TRP_8. Average CT measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (C) and the contralateral (D) sides of all 3 groups in TRP_{30}. Bars represent the standard deviation of all measurements recorded over the total recording period.*

was cooler by 2.34°F (±0.18°F) in average for all 3 groups (Fig 1A), that is, 3.0°F for the treatment group, 2.2°F for the sham group, and 2.3°F for the control group. Figure 1B (TRP_{30}) shows that there were no consistent between-group differences comparing the CT measurements of the ipsilateral and the contralateral sides.

Furthermore, the tests main effect ($F_{5,\ 300}$ = 10.548, $P <$ .000, power = 0.999) along with the tests by periods ($F_{5,\ 300}$ = 4.485, $P <$ .001, power = 0.970) and the different sides by tests (sides by tests: $F_{5,\ 300}$ = 4.899, $P <$ .001, power = 0.981; sides by tests by period: $F_{5,\ 300}$ = 3.683, $P <$ .003, power = 0.928; sides by tests by periods by groups: $F_{10,\ 300}$ = 2.016, $P <$ .032, power = 0.882) interactions were found to be statistically significant, revealing a different test adaptation from one side to the other and from one period to the other. For instance, Figure 2A, B shows the average CT measurements for the ipsilateral and contralateral sides of the treatment, sham, and control groups for TRP_8. The ipsilateral side (subluxation side on Fig 2A) was cooler than the contralateral side (control side on Fig 2B). This difference holds true throughout the total recording period (from t_{-2} through t_{10}) and all groups. However, CTs in the sham and control groups from $t_{-0.5}$ to t_{10} appear almost identical on their respective sides, whereas the CT in the treatment group appears systematically lower. Specifically, the treatment group CT on the ipsilateral side showed an effect starting from t_0, whereas the contralateral side CT behaved similarly to the other groups while being slightly colder.

Figure 2C, D shows the average CT measurements taken from the ipsilateral and contralateral sides for the treatment, sham, and control group for TRP_{30}. There was a mix of temperature ranges with no consistent pattern, except for a warming trend starting at t_1 for all groups and on both sides. Figure 3 shows the groups by sides by tests information from TRP_8 and TRP_{30} expressed as the difference from the initial value at $t_{-0.5}$. For TRP_8, Figure 3A shows a cooling in the treatment group CT on the ipsilateral side at the moment of the adjustment. After the adjustment (after t_0), there was a warming over time on the ipsilateral side followed by a second cooling-warming sequence starting at t_5. However, the ipsilateral CT progression for the sham and control groups was almost identical. Figure 3B also illustrates that

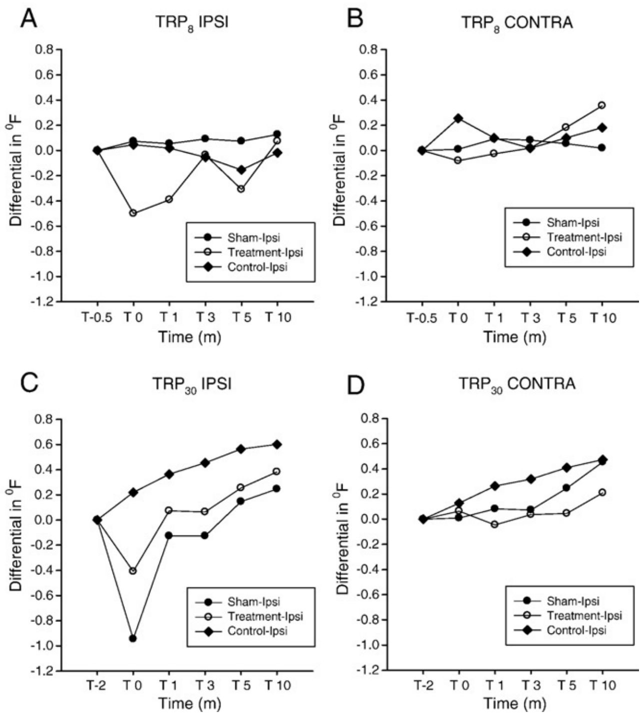

Fig 3. *Average temperature differential of the CT in relation to the $t_{-0.5}$ time sequence measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (A) and the contralateral (B) sides of all 3 groups in TRP_8 and average temperature differential of the CT in relation to the t_{-2} time sequence measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (C) and the contralateral (D) sides of all 3 groups in TRP_{30}. Bars represent the standard deviation of all measurements recorded over the total recording period.*

the contralateral side of the sham and control groups remained relatively stable. In the treatment group (Fig 3B), there was a continued warming from t_0 until t_{10}. Figure 3C shows the effect of the treatment and sham groups for the TRP_{30} period. After t_0, there was a warming of the CT with time on the ipsilateral side. From t_1, the progression was very similar for all 3 groups and both sides. As shown in Figure 3D, all 3 groups expressed a similar CT pattern.

Discussion

The main finding is that an MAMF adjustment (treatment groups in both TRP_8 and TRP_{30}) as well as a sustained mechanical pressure, higher than what is recommended by the AMCT treatment protocol (sham group in TRP_{30}), produced an immediate cooling in CT followed by a normalization of the CT that takes place within 3 minutes after the adjustment. However, the CT adaptation in response to the adjustment during TRP_8 reveals 2 cooling-warming cycles: the first occurring between t_0 and t_3 and the second between t_3 ant t_{10}. Furthermore, when a mechanical pressure at the recommended level is applied (sham group in TRP_8), no CT adaptation is measured. This suggests that acute CT cooling may occur specifically in response to an MAMF adjustment executed as recommended, or because of a high and sustained pressure. The following discussion suggests the possible theories and mechanisms that may help explain the measured CT response or adaptation.

Physiological Responses to a Mechanical Stimulation

The initial decrease in CT on the ipsilateral side associated with the MAMF adjustment (treatment groups in both TRP_8 and TRP_{30}) and the sustained mechanical pressure (sham group in TRP_{30}) may be interpreted as a cutaneous circulation response to the mechanical stimulus that produces a change in the local blood flow. Blood flow has a thermoregulatory response that can vary by as little as 1 mL/100 g of skin to as much as 150 mL/100 g of skin.[22] The 2 reactions to a mechanical stimulus include a whitening reaction and a reddening reaction.[22,23] The whitening reaction is indicative of a contraction of the precapillary sphincters. This response appears after a light mechanical contact on the skin. This precapillary sphincter contraction reduces cutaneous blood flow and could be responsible for the cooling measured on the ipsilateral side.

The postadjustment (t_0 to t_3) warming on the ipsilateral side (Fig 3C) may be interpreted as a reddening reaction that appears when the skin is more firmly stroked, producing a longer-lasting effect. This whitening/reddening response has 3 stages: (1) the whitening reaction is the initial skin reaction produced by the mechanical deformation of the skin due to the adjustment or pressure application; (2) the reddening reaction is a capillary dilatation, a direct response to the mechanical thrust or pressure; and finally, (3) local swelling could ensue because of the increased permeability of the capillaries and venules. It is also important to note that reddening could appear because of arteriolar dilatation. This 3-stage response is a normal adaptive reaction to a mechanical stimulus applied to the skin and is considered the result of an axonal reflex.[22,23]

According to Ganong,[22] impulses from the sensory nerves are relayed antidromically along other branches of sensory nerve fibers. This could be a reaction of the skin as it receives a potent mechanical stimulus[24]: a prolonged mechanical stimulation (5 seconds) and 200 N in 1.0 millisecond, such as in the treatment group, or a prolonged mechanical stimulation (5 seconds) from the pressure application, such as in the sham group. According to Aller et al,[25] mechanical energy can stimulate the endothelium, which plays an important role in regulating the vascular system. In addition, when stimulation is too strong, such as during a muscle spasm or sustained pressure, a generalized cutaneous vasoconstriction may occur in addition to the local 3-stage response. Therefore, a reactive hyperemia hypothesis could be considered. Accordingly, as the muscle spasms due to the adjustment subside, the amount of blood in the region's circulation is increased and reestablished after a period of occlusion. This cascade of events could also take place in the presence of a chronic vertebral subluxation complex.

The role of segmental sympathetic reactions could also be entertained. Studies by Sato and Swanson[14] using an animal model and human studies by Budgell and Hirano[15] demonstrated a sympathetic response after a vertebral lateral flexion movement was induced. Pickard and Wheeler[16] investigated paraspinal muscle manipulation on the cat and determined that it is possible for sensory impulses to evoke visceral reflexes affecting the sympathetic nervous system. Such sympathetic nervous system reactions can help us understand the CT adaptation findings of this study. However, to confirm the herein suggested sympathetic reactions, other specific variables need to be measured, such as changes in heart rate variability by spectral analysis known to be associated with these reactions.[26,27]

The Physiological Immunological Response

Cooling at the time of the adjustment could be due to a compression of the local tissue reducing superficial blood flow as discussed. The rewarming of the area to its original level would be the expected response after the release of the tissue tension from the adjustment. The tendency for the adjusted area to keep warming due to increased perfusion would be helpful because it would remove residual inflammatory metabolites from the chronic injury site. We must be aware that no known vasodilator nerve fibers extend to cutaneous vessels. The vasodilatation is possibly brought forth by a decrease in constrictor tone of the sympathetic nervous system as well as local production of vasodilator metabolites (H^+, K^+ADP, NO, and cytokines).[21,26] Again, these hypotheses deserve scientific attention to be tested.

CT Adaptation to Thermoregulation Controls

Cutaneous temperature levels are directly related to thermoregulation functions.[22,23] Thermoregulation functions are controlled by the optic nucleus of the hypothalamus.[3] The neurological influx from thermogenesis centers stimulates the sympathetic nerves connected to blood vessels.[3] The CT response can be seen as a 2-level assessment/reassessment of the individual temperature that implies the coordination of 2 control levels over time in the following fashion: (1) the acute CT normalization (from t_0 to t_3) is controlled locally through segmental reactions, as discussed above, whereas (2) the CT normalization occurring from t_3 to t_{10} may represent the implication of a higher center in the hypothalamus, which could produce a release of vasodilator metabolites.

We also suggest that the CT adaptations measured might have to do with axonal reflexes, the release of some type of chronic muscle spasm, as well as normal tissue response to mechanical stresses. However, the continued warming could receive regulation from either a neurological supraspinal control or a physiological cellular reaction from either the vascular or the immunological systems. We posit that the information generated by the MAMF adjustment could be modulated by any of the 3 systems previously mentioned.

Finally, a significant difference in CT between the adjusted (ipsilateral) and the nonadjusted (contralateral) sides was found in TRP_8. This difference could be associated with a normal blood perfusion of local tissues or with a segmental sympathetic reflex reaction mediated through skin sensory receptors in reaction to the tissue compression. Again, these hypotheses require further research.

Other Considerations

The CT measurements taken during TRP_8 appeared to be more susceptible to changes, demonstrating systematic side and treatment effects. Our results, taken at TRP_8, also show a consistent cooling of 2.34°F (±0.18°F) on the side of the subluxation. Hence, we recommend recording of CT measurements when the patient has acclimatized for 8 minutes in a controlled environment until the limit of the 8-minute recording period (TRP_8), which is the 16th-minute mark.

Conclusion

Contacting the skin with the instrument with (treatment group TRP_{30}) or without (sham group TRP_{30}) a thrust with a sustained pressure stronger than the loading principle taught in the AMCT protocol or a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument produced a CT cooling immediately after the adjustment. Furthermore, we observed that when contacting the skin with the instrument with a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument, it produced a secondary cooling at t_5 followed by a rewarming at t_{10}. Finally, contacting the skin with the instrument without a thrust and respecting the standard loading principle (sham TRP_8) of the instrument did not produce a CT change. At present, these findings do not imply clinical effectiveness. More research needs to be done to understand the neurological, vascular, and immunological mechanisms involved in the control of CT adaptations to external stimulation or dysfunction. Future research will bring both researchers and clinicians closer to a better understanding of the effects of chiropractic adjustments and their relationship to CT adaptations.

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