

# Immediate effects of upper thoracic manipulation on the skin surface temperature of the vertebral region in healthy women

*Efeitos imediatos da manipulação torácica alta sobre a temperatura superficial cutânea da região vertebral em mulheres saudáveis*

*Los efectos inmediatos de la alta manipulación torácica de la temperatura superficial de la piel en la región vertebral en mujeres sanas*

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**ABSTRACT** | Manipulation of the spinal column is a manual therapeutic resource characterized by passive thrust of a given joint at a high velocity and low amplitude within the limits of anatomic integrity. The objective of the present study was to assess the immediate effects of upper thoracic manipulation on skin temperature in the vertebral region in healthy women. Thus, a randomized controlled blind trial was realized in the university community. Twenty-six healthy women were randomly allocated into an experimental group (n=13) and a placebo group (n=13). A single session of upper thoracic spine manipulation (segment T3) was performed. Infrared thermography was used to determine changes in skin temperature in the vertebral region. Images were taken prior to, immediately after and both five and 10 minutes after manipulation. Two-way repeated measures analysis of variance with post hoc Bonferroni test was used for inter and intragroup comparisons. The level of significance was set to 5%. No significant differences were found between the different evaluation times in either group ( $p>0.05$ ). In the intergroup analysis, no statistically significant differences were found in any of the comparisons ( $p>0.05$ ). Based on the method employed, thoracic spine manipulation of the T3 vertebral segment does not promote changes in skin surface temperature in the region manipulated in asymptomatic individuals.

**Keywords** | Thermography; Skin Temperature; Spinal Manipulation; Physical Therapy Modalities.

**RESUMO** | A manipulação da coluna vertebral é um recurso da terapia manual caracterizado por um impulso passivo de alta velocidade e baixa amplitude dentro dos limites de integridade anatômica de uma articulação (*thrust*). O objetivo do presente estudo foi avaliar os efeitos imediatos da manipulação torácica alta sobre a temperatura superficial cutânea da região vertebral em mulheres saudáveis. Para tal, foi realizado um estudo clínico randomizado cego na comunidade universitária. Vinte e seis voluntárias saudáveis foram alocadas de forma randomizada em um grupo experimental (n=13) e um grupo placebo (n=13). Uma sessão de manipulação torácica alta (segmento T3) foi realizada. Foi empregada a termografia infravermelha para determinar alterações na temperatura cutânea na região vertebral. Imagens foram capturadas antes, imediatamente após, cinco e dez minutos após a manipulação. Foi usada análise de variância com medidas repetidas (dois critérios) seguida do teste de Bonferroni para as comparações inter e intragrupos. Adotou-se um nível de significância de 5%. Não foi encontrada diferença significativa nas diferentes avaliações ao longo do tempo ( $p>0,05$ ). Na análise intergrupos, não foi constatada

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diferença significativa nas comparações realizadas ( $p > 0,05$ ). Com base na metodologia empregada, a manipulação torácica do segmento vertebral T3 não promoveu alterações na temperatura superficial cutânea na região manipulada.

**Descritores** | Termografia; Temperatura Cutânea; Manipulação Vertebral; Modalidades de Fisioterapia.

**RESUMEN** | La manipulación de la espina dorsal es un recurso de terapia manual que se caracteriza por un impulso pasivo de alta velocidad y baja amplitud de los límites de integridad anatómica de una articulación (*thrust*). Esta investigación tuvo por objetivo evaluar los efectos inmediatos de la alta manipulación torácica de la temperatura superficial de la piel en la región vertebral en mujeres sanas. Para eso, se ha realizado un estudio clínico aleatorizado ciego en la comunidad universitaria. Veintiséis voluntarias han sido puestas de forma aleatorizada en un grupo experimental ( $n=13$ ) y un grupo placebo ( $n=13$ ). Ha sido

realizada una sesión de manipulación torácica alta (segmento T3). Se ha empleado el término infrarrojo para determinar alteraciones en la temperatura de la piel en la región vertebral. Se han capturado imágenes antes, inmediatamente después, cinco y diez minutos tras la manipulación. Se ha hecho un análisis de los cambios con medidas repetidas (dos criterios) seguido de la prueba de Bonferroni para las comparaciones inter e intragrupal. Se ha adoptado un nivel de significancia de 5%. No ha sido encontrado diferencias significativas en las diferentes evaluaciones al largo del tiempo ( $p > 0,05$ ). En el análisis intergrupar, no ha sido constatado diferencias significativas en las comparaciones realizadas ( $p > 0,05$ ). Basándose en la metodología empleada, la manipulación torácica del segmento vertebral T3 no cambió la temperatura superficial de la piel en la región estudiada.

**Palabras clave** | Termografía; Temperatura cutánea; Manipulación Espinal; Modalidades de Fisioterapia.

## INTRODUCTION

Manipulation of the spinal column is a manual therapeutic resource characterized by passive thrust of a given joint at high velocity and low amplitude within the limits of anatomic integrity. The aim is to restore the movement and function of the manipulated segment<sup>1-3</sup>. Thoracic manipulation is the most often employed physical therapy method in clinical practice<sup>4</sup> due to its benefits and the fact that it poses fewer risks in comparison to other techniques, such as cervical spine manipulation<sup>5-7</sup>.

A number of studies have demonstrated neurophysiological changes following spinal column interventions<sup>8,9</sup>. Sterling, et al.<sup>10</sup> found a reduction in skin temperature in the palmar region of the thumb (measured using sensors) following cervical mobilization, suggesting that this technique stimulates the sympathetic nervous system. Jowsey and Perry<sup>11</sup> also found stimulation of the sympathetic nervous system following thoracic spine mobilization, as determined by skin conductance in the hands.

Infrared thermography captures the superficial skin temperature, which can indicate the activity of the sympathetic nervous system. This is due to the fact that the autonomic system influences the

microcirculatory activity and hence the temperature of the skin<sup>12</sup>. Infrared thermography offers the advantages of being painless, non-invasive and capable of detecting, recording and producing infrared images reflecting the microcirculation dynamics of the skin surface in real time<sup>13-15</sup>. Infrared thermography has been employed to measure physiological responses to therapeutic procedures<sup>16,17</sup> and assess musculoskeletal disorders<sup>18,19</sup>. A number of researchers report that this tool can also be used to assist in the diagnosis of different pathological conditions<sup>20-23</sup>.

Based on the findings of the studies cited above, the hypothesis of this study is that upper thoracic manipulation promotes changes in the activity of the sympathetic nervous system in asymptomatic individuals without thoracic restriction. The clinical importance of this study resides in the fact that few investigations have addressed the physiological effects of spinal manipulation on the autonomic nervous system. Thus, a better understanding of the mechanisms involved will allow greater treatment efficacy and the minimization of possible risks.

The aim of the present study was to assess the immediate effects of upper thoracic manipulation on skin surface temperature in the region of the T3 vertebra in healthy female university students.

## METHODOLOGY

### Study design

A randomized controlled blind study was carried out. The volunteers were unaware of which technique they were receiving and the researchers in charge of the image capturing and data analysis were also blinded to which group the participants were allocated into.

This study received approval from the Human Research Ethics Committee of the Methodist University of Piracicaba (SP, Brazil), registration number 60/12. This study is registered at clinicaltrials.gov (NCT01872676).

### Sample

Twenty-seven healthy women between 18 and 30 years of age ( $22.37 \pm 3.32$  years) were recruited from the university community of the city of Piracicaba (SP), Brazil. The exclusion criteria were: use of vasoactive medication; body mass index (BMI) greater than  $25 \text{ kg/m}^2$ ; having undergone spinal manipulation in the previous month<sup>24</sup>; and any red flag, such as a malignant

tumor or inflammatory or infectious disease that contraindicates manual therapy<sup>25</sup>.

After the application of the eligibility criteria, one individual refused to participate. Thus, the final sample was made up of 26 volunteers. By means of block randomization and concealing the allocation using opaque envelopes, they were randomly allocated into two groups: an experimental group with 13 volunteers, mean age of  $21.91 \pm 2.84$  years, mean BMI of  $20.89 \pm 2.15 \text{ kg/m}^2$ , submitted to upper thoracic manipulation; and a placebo group with 13 volunteers, mean age of  $22.58 \pm 3.33$  years, mean BMI of  $20.76 \pm 2.58 \text{ kg/m}^2$ , submitted to a maneuver with no therapeutic effect on the thoracic region. Further details are displayed in the flowchart of the study (Figure 1).

### Infrared thermography

Skin temperature in the region of the T3 vertebra was measured using a thermal camera (T360 model, FLIR Systems, Danderyd, Sweden), with emissivity established at 0.98 and stabilized 10 minutes prior to the thermographic exam.

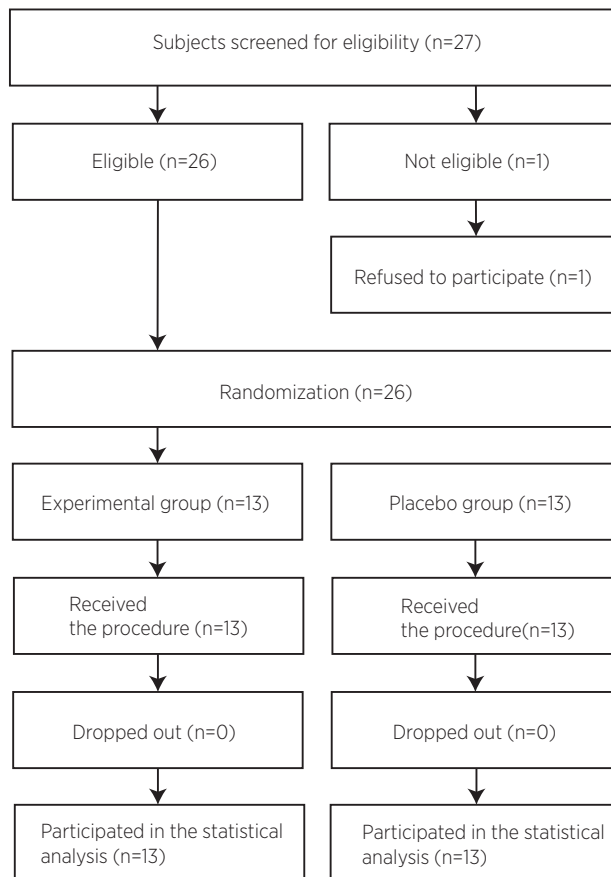


Figure 1. Flowchart of the study

The volunteers remained in a room for 20 minutes with controlled temperature ( $22\pm 1^\circ\text{C}$ ) and lit with fluorescent bulbs to avoid heat sources, without the presence of heat-generating electrical equipment or the incidence of direct air or sunlight. The participants were instructed to avoid alcohol, tobacco, physical exercise, bath or shower, deodorants, lotions<sup>16,19</sup> and the ingestion of stimulating substances, such as caffeine, or the use of nasal decongestants for four hours prior to the exam<sup>15,19,26</sup>.

During the data collection, the volunteers remained standing with the trunk erect. The region to be analyzed was maintained free of clothing. The image was captured at a distance of 100cm from the T3 vertebra to allow the proper framing of the region of interest. Styrofoam markers were used to delimit the regions of interest and facilitate the analysis of the infrared images due to the isolating property of the material. Three Styrofoam markers (10mm in diameter) were used to delimit the area where the temperature would be measured. The markers were placed over the transverse process of the T3 vertebra and 5cm to both the right and left of the vertebra. The skin surface temperature of the region over the T3 vertebra was analyzed based on the measurement of the area between the central marker and those positioned on the right and left sides (Figure 2).

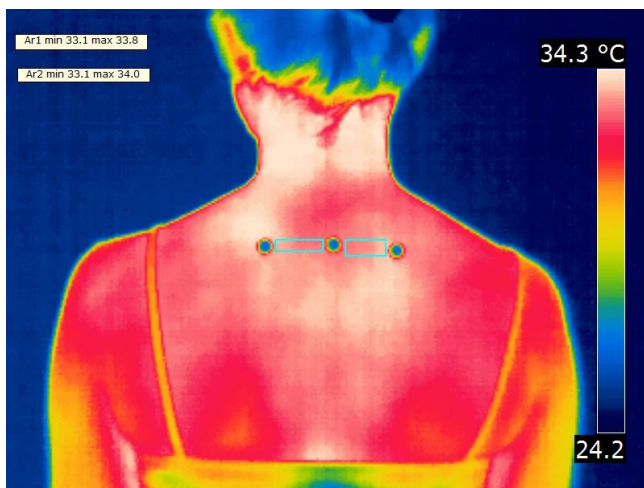


Figure 2. Measurement of skin surface temperature in the region of the T3 vertebra

The thermographic exam was performed prior to manipulation (T0), immediately after manipulation (T1) and both five (T5) and ten minutes (T10) after manipulation. Three images were taken of each volunteer under each condition and the mean of the readings was used for the purposes of analysis. The “area” tool of the QuickReport software version 1.1 (FLIR Systems)

was used to determine the temperature. The absolute temperature of each region was measured and asymmetry was determined by subtracting the temperature on one side from that on the other side.

## Experimental procedure

The experimental group received a high-velocity, end range force applied through the elbows to the upper thoracic spine on the T3 vertebra spine in cervicothoracic flexion, with the patient positioned supine. The therapist positioned a stabilizing hand in a “pistol grip” immediately caudal to the T3 vertebra, pushing the volunteer’s arms downward to generate flexion of the upper thoracic spine (Figure 3). Once this pre-manipulation position was achieved, the volunteer was instructed to inhale deeply; at the end of the expiration, a high-speed, short-amplitude thrust was performed in the posterosuperior direction.

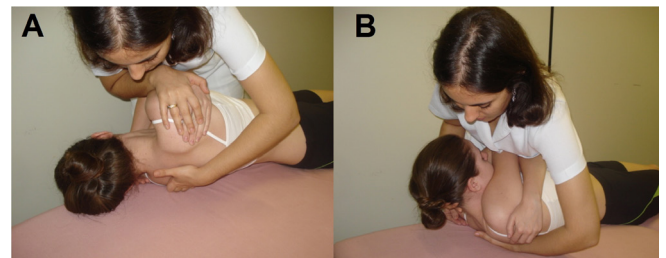


Figure 3. Initial (A) and final (B) position of upper thoracic manipulation of the T3 vertebral segment

In cases in which audible cavitation occurred following the first manipulation attempt, the volunteer was submitted to immediate evaluation. In negative cases, the volunteer was repositioned and the thrust was repeated. A maximum of 2 attempts for each technique was allowed, regardless of having achieved joint cavitation<sup>27</sup>.

The placebo group was placed precisely like the experimental group, with the exception of the positioning of the therapist’s hand, which remained with the palm open and not in a “pistol grip”, based on the methods described in studies by Cleland, et al.<sup>4</sup> and Cleland, et al.<sup>28</sup>. Once positioned, the volunteers were instructed to breathe deeply. The maneuver was terminated after one cycle of deep breathing, without high-speed, short-amplitude thrust.

## Statistical analysis

The sample size was calculated based on the skin surface temperature of the region to the right of the T3

vertebra immediately after manipulation (determined in the pilot study). The following parameters were used: mean of the experimental group (33.46°C), mean of the placebo group (32.44°C) and standard deviation of the overall sample (0.76°C). The calculation was performed to yield an 80% statistical power and alpha of 0.05, using the Ene software version 3.0 (Barcelona, Spain), which determined a number of 10 volunteers in each group.

The Shapiro-Wilk test was used to determine the normality of the data. Two-way repeated measures analysis of variance with post hoc Bonferroni test was used for inter and intragroup comparisons. Intraclass correlation coefficient (ICC<sub>2,1</sub>) was used to determine the intra-rater reliability, based on the three repetitions of the infrared image analysis. Interpretation of ICC values was based on that suggested by Fleiss<sup>29</sup>. For values lower than 0.40, the reliability was considered low; between 0.40 and 0.75, moderate; between 0.75 and 0.90, substantial; and finally, values greater than 0.90, excellent. The level of significance was set to 5% (p<0.05) for all comparisons. Statistical analysis was performed using the SPSS program, version 13.0 (Chicago, IL, USA).

## RESULTS

Table 1 displays the results of the intra and intergroup comparisons of the skin surface temperature of the region of the T3 vertebra as well as the temperature asymmetries at T0, T1, T5 and T10. No statistically significant differences were found in any of the comparisons (p>0.05).

With respect to reliability, excellent ICC values were observed, as follows: T0, left (ICC=0.988) and right (ICC=0.987); T1, left (ICC=0.992) and right (ICC=0.988); T5, left (ICC=0.993) and right (ICC=0.992); T10, left (ICC=0.993) and right (ICC=0.990).

## DISCUSSION

The present findings demonstrate no changes in skin surface temperature in the manipulated thoracic region. The literature is scarce regarding the assessment of skin surface temperature or the autonomic nervous system during spinal manipulation. In a study carried out by Chiu and Wright<sup>30</sup>, stimulation of the sympathetic nervous system through grade III mobilization of the C5 vertebra resulted in vasoconstriction, with a consequent reduction in skin blood flow and temperature of the C6 dermatome in asymptomatic individuals.

Moulson and Watson<sup>31</sup> performed Mulligan's technique in a sustained fashion on the C5-C6 intervertebral joint in asymptomatic individuals and found an increase in skin conductance as well as a tendency toward a reduction in skin temperature, indirectly reflecting stimulation of the sympathetic nervous system. Sterling, et al.<sup>10</sup> report similar results in a study assessing the effects of cervical mobilization on the autonomic nervous system in individuals with neck pain.

The present investigation differs from the studies cited above with regard to the proposed treatment, as manipulation was performed of the thoracic segment, with the evaluation of skin surface temperature on the T3 region. It is important to investigate the effects stemming from spinal manipulation, as this resource is commonly employed in physical therapy to restore joint function. Spinal manipulation is characterized by passive movement of a joint beyond its passive active limit of motion, but within the limits of its anatomic integrity, and generally constitutes a localized thrust of high acceleration and low amplitude<sup>3</sup>.

A recent placebo-controlled study found that grade III mobilization of the T4 vertebra led to an increase in sympathetic activity in the hands of healthy individuals, as determined through an analysis of skin conductance<sup>11</sup>. In the present study, infrared thermography was employed to evaluate the temperature of the region in which the

Table 1. Intra and intergroup comparison of skin surface temperature in regions evaluated in the pre-manipulation period (T0), immediately after manipulation (T1) and both 5 (T5) and 10 minutes after manipulation (T10). Values expressed as mean and standard deviation

Group	Region	T0	T1	T5	T10
EG	RT3	33.21 (0.56)	32.93 (0.64)	33.17 (0.49)	33.19 (0.54)
	LT3	33.22 (0.56)	33.11 (0.58)	33.21 (0.48)	33.21 (0.54)
	AT3	0.14 (0.10)	0.26 (0.20)	0.18 (0.13)	0.13 (0.15)
PG	RT3	32.88 (0.63)	32.53 (0.38)	32.67 (0.49)	32.81 (0.59)
	LT3	32.88 (0.56)	32.58 (0.63)	32.68 (0.55)	32.85 (0.57)
	AT3	0.31(0.14)	0.35 (0.30)	0.30 (0.21)	0.26 (0.23)

EG: Experimental group; PG: Placebo group; RT3: Right T3 vertebra; LT3: Left T3 vertebra; AT3: Temperature asymmetry of T3 vertebra  
No intra and intergroup differences (2-way repeated measures ANOVA with post hoc Bonferroni test, p>0.05)



experimental procedure was performed. Further studies should be carried out to assess skin temperature in the palmar region following thoracic manipulation, as performed in the study by Sterling, et al.<sup>10</sup> using cervical mobilization. Infrared thermography was employed to assess sympathetic activity in the present study due to the fact that this method allows detecting changes in skin surface temperature, which indirectly reflects autonomic activity<sup>17</sup>.

Puhl and Injeyan<sup>24</sup> found no changes in plasma levels of mediators of the activity of the sympathetic nervous system (epinephrine and norepinephrine) immediately following upper thoracic manipulation of the hypomobile segment in healthy individuals. However, the authors do not discard the theory of altered sympathetic activity following manipulation.

A number of studies have employed infrared thermography to investigate changes in skin surface temperature during physiotherapeutic interventions on the spinal column. Evaluating the results of connective tissue massage through an analysis of skin surface temperature, Holey, et al.<sup>17</sup> found that the intervention produced little effect on the autonomic nervous system and state that infrared thermography allows the observation of neurovegetative behavior.

The present findings do not lend support to the explanation offered by Roy, et al.<sup>32</sup>. The authors found a change in skin surface temperature in individuals submitted to manually assisted mechanical force in the lumbar region and attribute this finding to the axon reflex caused by the stimulus, which involves an initial reduction in blood flow due to the mechanical compression stemming from the technique employed, followed by capillary dilation in direct response to the force applied, with a consequent increase in the permeability of venules and capillaries.

Infrared thermography captures skin temperature, allowing an indirect evaluation of localized blood flow and the activity of the autonomic nervous system<sup>17,33,34</sup>. However, a number of authors report that changes in skin temperature stemming from physiotherapeutic interventions are less substantial than the effect produced on skin conductance<sup>9,10,30</sup>.

According to Pickar<sup>35</sup>, spinal manipulation may generate excitatory and inhibitory effects on somatomotor activity. Thus, sensory stimuli of the paravertebral tissue may cause visceral reflexes that affect the sympathetic nervous system and consequently alter the function of target organs. The author states that non-harmful paravertebral sensory stimuli generally have an inhibitory

effect on sympathetic flow, whereas harmful stimuli trigger an excitatory effect.

Regarding to the effects of the manipulation on the autonomic nervous system, it was expected that in this study the technique generated an inhibition in the sympathetic nervous system, which would be responsible for the increase in the temperature on the region<sup>36,37</sup>. However, the present study has limitations that should be addressed. Individuals with restricted mobility in the manipulated segment and/or pain upon palpation were not included, despite recent studies with similar objectives have been carried out on healthy individuals as well<sup>11,17,31,32</sup>.

Still in this context, only female subjects were analyzed in the present study. The study population constituted a convenience sample. A single session was applied; thus, it is unknown whether multiple sessions would have a cumulative effect. However, studies have demonstrated changes in the activity of the sympathetic nervous system following a single session of manipulation or mobilization<sup>5,10,38</sup>.

In the present study, we chose to evaluate only the manipulated region due to force applied on it, but it would be appropriate if future studies considered the region of the corresponding dermatome. Furthermore, the absence of baseline period is considered a limitation of the study, which must be corrected in future studies.

Finally, although the present study provides a priori sample size calculation, it is suggested that future studies be conducted with a larger sample, given that a clinical trial with fewer than fifteen volunteers per group assumes a significant risk of committing a type II error.

## CONCLUSION

Based on the employed method, thoracic spine manipulation of the T3 vertebral segment does not promote changes in skin surface temperature in the manipulated region.

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