

Correlation of thermography with spinal dysfunction: preliminary results

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The results of a blinded pilot study researching the correlation of thermographic abnormalities and spinal segmental dysfunction are presented. The highest agreement resulted between focal increases in thermal emission and fixation (64.7%). Other parameters studied were tenderness and textural skin changes which agreed with thermographic findings 63.7% and 59.9%, respectively. Correlation coefficients were calculated for each subject and reasons for the wide range ($r = .14$ to $.77$) were discussed. Discussion of this research design and suggestions for future study were also presented. (JCCA 1988; 32(2): 77-80)

KEY WORDS: thermography, fixation, tenderness, skin rolling, chiropractic.

Les résultats d'une étude d'essai à l'insu sur la corrélation des anomalies thermographiques et la dysfonction segmentaire de la colonne vertébrale sont ici présentées. La plus grande conformité a été le résultat entre l'augmentation focale dans l'émission thermique et la fixation (64,7%). Des études supplémentaires ont démontré une sensibilité et un changement de texture de la peau en accord avec les résultats thermographiques, 63,7% et 59,9% respectivement. Les coefficients de corrélation ont été calculés pour chaque patient et la raison de leur grande différence ($r = .14$ à $.77$) a été discutée. On a aussi soumis des suggestions pour de futures études après discussion de cette formule de recherche. (JCCA 1988; 32(2): 77-80)

MOTS CLÉS: thermographie, fixation, sensibilité, prélèvement d'un greffon, chiropraxie.

Introduction

Thermography is basically photography of heat emissions. In the health care field, thermography is playing an ever more important role in the diagnosis of disease^{1,2,3}. Although modern thermography is less than 30 years old, its applications range from breast cancer screening, to carotid artery stenosis detection, to evaluation of neuromusculoskeletal problems. Research into this last field is increasing significantly, not only fueled by the spiralling costs encountered in the treatment of musculoskeletal problems, but also due to the attractiveness of thermography's objective, non-invasive and low-risk characteristics.

The chiropractic profession also has an historical involvement in the detection of bodily heat emissions for diagnostic purposes. The neurocalometer was a heat-sensing device promoted by BJ Palmer in 1924⁴. It was the forerunner of a series of instruments which used thermocouples placed in contact with the skin to sense surface heat. Later, Adelman and Kimmel used an instrument called the analyte which evaluated the light reflection from hemoglobin in surface capillaries⁵. More recently, both infrared sensing equipment and cholesteric ester solutions (liquid crystals) have been used to study spinal segmental dysfunction^{6,7}.

Although widely recommended as a means of providing objective evidence of segmental dysfunction by chiropractic thermographers, there is a paucity of controlled investigations correlating thermographic abnormalities with spinal dysfunction^{8,9}. Further, there is some discrepancy in description of shape and location of the thermographic findings caused by spinal dysfunction. McFadden describes crescent-shaped areas of increased thermal emission lateral to the spine which he correlated with facet syndrome¹⁰. Wexler, however, describes circular, focal areas of hyperthermia lateral to the spine¹¹.

Complex combinations of the proceeding two descriptions, as well as centrally located focal areas of hyperthermia, are proposed by Chapman to correspond to different categories of spinal dysfunction⁸.

Reports from Europe differ quite extensively from these descriptions. In fact, Durianova and Engel, during three separate investigations, describe hypothermic zones appearing paraspinally which they ascribe to segmental spinal dysfunction^{12,13,14}. Engel also reported warming of hypothermic areas in response to spinal manipulation¹². This would seem to be in direct contrast to the North American experience.

This study was designed to investigate the relationship between thermographic abnormalities overlying or adjacent to the spine and palpatory indicators of spinal segmental dysfunction. The palpatory indicators chosen were fixation, tenderness to palpation and textural changes noted upon skin rolling. Fixation, or restricted segmental mobility was detected by passive joint challenge techniques. Restrictions in joint mobility have become well accepted criteria for the presence of spinal segmental dysfunction. Tenderness over the spinous process also has a long history of association with spinal dysfunction^{15,16}. As well, textural changes noted upon skin rolling have been used as indicators of spinal dysfunction by osteopaths, chiropractors and medical doctors for years, and have received renewed interest lately as objective evidence of low-back pain^{17, 18}. For the purposes of this study then, segmental dysfunction was defined by the three indicators of fixation, tenderness, and textural skin changes. Thus, the presence of all three indicators at the same level increased the certainty that segmental dysfunction existed at that level.

Materials and methods

The thermography was conducted in a temperature controlled, draughtless room, using a Flexitherm® Mark II liquid crystal thermography unit. Standard protocol as described elsewhere, was followed¹⁹. Thermograms of the complete thoracic, lumbar

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and sacral areas were taken with markers set at the spine of the scapula, the inferior angle of the scapula, the T12-L1 junction and the iliac crest. Thermograms were permanently recorded on Fujichrome 50 ASA slide film with a Pentax Program Plus camera and 1:2 50 mm. lens. All thermograms were read by one of the authors (PRP Diakow), an experienced thermographer certified by the American Board of Clinical Thermology.

Thermograms were considered positive at a particular spinal level if a centrally or paraspinally located focal area was found to be distinctly hyperthermic or hypothermic. A temperature difference of 1°C between a localized area and its surrounding area was considered significant.

Palpation was performed by another member of the research team who was blinded to the thermographic findings. All subjects except #9 were palpated by the same examiner.

The sample consisted of 10 volunteers all with a history of spinal segmental dysfunction but not in acute pain at the time of examination. Five were males and five were females, with ages ranging from 23 to 37 years.

Results

Table I displays the agreement between thermography and the indicators of segmental dysfunction. The average agreement across all subjects for the combined palpatory examination is 55.3%. If the hypothermic findings are also considered, the average for the combined palpatory examination agrees with thermography 56.8%. Although the highest correlations occur between thermography and fixation (64.7%), the differences are small considering the size of this preliminary sample. All thermographic abnormalities found were hyperthermic foci except for 7 distinctly hypothermic areas, all found between T1 and T3. These hypothermic findings correlated with palpatory findings in 3 cases. One subject exhibited a central hypothermic focus with a focal hyperthermic area just lateral to it, which correlated with fixation and tenderness.

Subject 9 was palpated by a different examiner, and one will note that the agreements are markedly below those of other subjects. In such cases, it is difficult to assess the effect of differences between the palpators and the variability in agreement that is also seen among other subjects.

To better delineate the association between thermography and spinal segmental dysfunction, the Pearson Product-Moment Correlation coefficient ' r ' was calculated. This statistic is used to identify the degree of linear relationship that exists between two variables. To calculate ' r ', we converted the exact temperatures on the thermograms to a 7 point ordinal scale where 0 was assigned to 29.4°C, 1 was assigned to 30.3°C and so on until 6 represented 34.4°C. All thermographic temperatures over each segmental and adjacent area were then converted to this scale and listed as the x_i variable.

The y_i variable was calculated by giving each of the indicators of spinal dysfunction a value of 1. Thus, if there were no tenderness, textural changes or fixation found at T3, then Y_{T3} would have a value of 0. If any one of these indicators were

Table I Agreement between thermography and joint dysfunction

Subject No.	Overall	Thermography fixation	Thermography tenderness	Thermography skin rolling
1	78.9%	84.2%	78.9%	84.2%
2	63.2%	68.4%	63.2%	63.2%
3	68.4%	73.6%	73.6%	68.4%
4	73.6%	73.7%	73.6%	73.7%
5	47.4%	63.2%	63.2%	52.6%
6	47.4%	57.9%	52.6%	47.4%
7	47.4%	68.4%	68.4%	47.4%
8	63.2%	73.6%	68.4%	78.9%
9	26.3%	26.3%	42.1%	36.8%
10	36.8%	57.9%	52.6%	47.3%
Averages	55.3%	64.7%	63.7%	59.9%

Table II Pearson r for each subject

Subject	r	r^2
1	.14	.020
2	.28	.078
3	.76	.58
4	.68	.46
5	.52	.27
6	.59	.35
7	.77	.59
8	.49	.24
9	.29	.084
10	.56	.31

found, Y_{T3} would have a value of 1, and so on. This scale implies that there is a greater chance that segmental dysfunction exists at a level when there are more indicators present at the same time. The number of levels measured was 19 (12 thoracic, 5 lumbar and 2 sacroiliac joints). The r and r^2 values are listed in Table II. r^2 varies from .078 to .59. In two of the subjects (subject 3 and 7) segmental dysfunction accounted for over half of the variation in segmental surface temperature.

Discussion

Although the results of this pilot study showed moderate agreement, the correlations calculated were poor except in two subjects. The original study design did not include the calculation of a correlation statistic. In retrospect, the authors believe that minor changes in experimental conditions would better suit data collection for the calculation of Pearson's r . First, room temperature was maintained at 22°C for all subjects. Although each subject was given 15 minutes to equilibrate, the normal variation in their average surface temperatures gave some subjects "background" readings of 32.0°C or even 32.8°C. Focal hyperthermic areas were easily identified visually, however when temperature from these hotter individuals were converted to the 0 to 6 scale for analysis, the effect was that the range of

possible scores was restricted. Statistically, this lowers the resulting correlation²⁰. In fact, the two subjects with the highest correlations also had lower background temperatures recorded.

With this in mind, future studies should cool the subjects individually to obtain a predetermined "background" temperature. Instead of maintaining a room temperature to suit each individual which would be time consuming and cumbersome, the individuals may be artificially cooled with a water mist and blower technique. These techniques have been used widely to highlight thermal abnormalities and remove anomalies without changing the essential interpretation or reliability of the thermogram²¹. In so doing, a greater range of spinal temperatures will be produced, thereby providing the greatest opportunity to study the actual association between thermographic findings and palpation of spinal dysfunction.

The choice of palpation for spinal dysfunction to correlate with thermography was a difficult one. Unfortunately, there does not exist a "gold standard" for the detection of joint dysfunction; in fact, the reliability and validity of palpating for spinal dysfunction are not known. Nonetheless, palpation for tenderness, joint restriction and skin rolling are central to chiropractic diagnostics^{22,23,24}. This problem may be eliminated by the use of three palpators (as opposed to a "gold standard"), who would provide a consensus of opinion regarding positive or negative findings at each level²⁵, and still utilize our three aspects of joint dysfunction. These three qualities define what we are looking for, and may in fact represent different aspects of segmental dysfunction. It is possible that each of these attributes might correspond with temporal differences or differences in degree of severity. Tenderness or textural changes each may appear earlier or later in the complex process of dysfunction. Similarly, thermographic changes may also not appear until later in the process, thus resulting in poor correlation with earlier indicators. These relationships warrant further study.

Many of the thermographic abnormalities listed at levels not found to be dysfunctional are, in fact, adjacent to dysfunctional segments. There are two possible explanations. First, with only 4 markers to estimate the spinal level on thermograms, this may represent the resolution limits of defining spinal level. Although marking each segment would be impractical, two or three more markers, may increase the reliability of assigning thermographic findings to one spinal segment or another.

Alternately, it has been well established that within the sensory fields of an individual, adjacent nerve roots overlap extensively on the trunk²⁶. Therefore, aberrant neurological reflexes originating in one segment could affect thermal abnormalities in the suprajacent or subjacent levels. Perhaps this represents the "neurological resolution" of thermography. In any case, a large sample with attention to these details may help to clarify this relationship.

An important outcome of this preliminary investigation is the relatively low proportion of hypothermic areas or areas of abnormally decreased thermal emission. Contrary to the Euro-

pean literature, most of the spinal and paraspinal thermal abnormalities noted were increases in thermal emission. This discrepancy likely results from subject selection. Our subjects were all relatively healthy volunteers without disability. The studies of Durianova, and Engel utilized symptomatic subjects with chronic, painful syndromes^{12,13,14}. Alternately, McFadden and others have concentrated on acute cases^{6,10}. Could there be a difference in the thermal properties of acute vs. chronic segmental dysfunction?

In the present study, subjects 2, 3, and 8 all mentioned their "cold" spots as being chronic problems. Further, it has been established that recent nerve root or peripheral nerve injuries show increased thermal emission along the related dermatome, whereas chronic nerve injuries are imaged as 'cold' dermatomes²⁷. Perhaps the underlying mechanisms producing first hyperthermia, then hypothermia in nerve injuries could also operate to produce similar time-related thermal effects for spinal fixations. Further investigation should be designed to elucidate this aspect of the thermal-fixation relationship.

In conclusion, there is convincing evidence that thermography could provide objective evidence of segmental dysfunction. There are questions pertaining to the exact relationship, sensitivity, and the relationship of thermographic findings to chronicity which should be addressed in future studies.

Acknowledgements

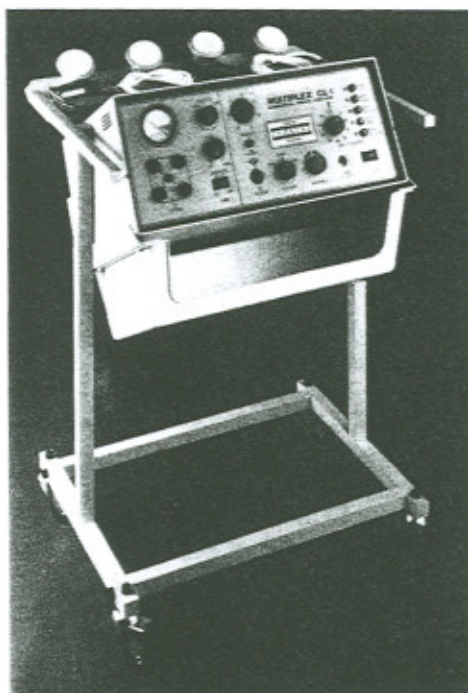
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