Preliminary Report:
The Thermal Characteristics of Spinal Levels Identified as Having Differential Temperature by Contact Thermocouple Measurement (Nervo Scope)

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ABSTRACT: *Objective:* To use computer-assisted infrared thermography in an attempt to generate a description of the thermal characteristics of spinal regions identified as having differential temperature by expert users of the Nervo Scope, a contact thermocouple instrument used in chiropractic clinical practice. *Design:* Prospective recording of the infrared thermographic images of prepared, stabilised subjects and then alternate presentation by each subject for blinded assessment by two expert users of the Nervo Scope instrument to identify spinal levels where there was agreement of the existence of a clinically relevant entity (known empirically as a "break") as indicated by the instrument's reponse to differential temperature, and then retrospective examination of those levels by computer-assisted analysis of the infrared thermographic images. *Setting:* Four rooms within a controlled laboratory setting at The Chiropractic Unit of RMIT University, Melbourne. *Subjects:* Eighteen (18) male and 13 female (n = 31) humans with informed consent as volunteers from a late adolescent/young adult student population without any declared clinical symptomatology. *Intervention:* Nil. *Main Observations:* Five (5) subjects were identified where there was agreement for appropriate evidence of spinal dysfunction at a particular spinal level. Thermal analysis of the paraspinal region about the found levels revealed a left/right difference of typically about 0.3°C and no greater than 1.1°C, and a series range on any one side of the spine of typically 1.0°C and no greater than 1.4°C. A particular characteristic was found, namely that an asymmetrical thermal dynamic existed between the paraspinal temperature gradients at these levels, meaning that the skin temperature varied asymmetrically, with one side falling while the other side increased. *Conclusions:* The circular graphs (radar plots) of the data clearly demonstrate the presence of an asymmetrical thermal dynamic which may, if replicated in other laboratories, represent an objective dimension of spinal dysfunction, or in more common terms, the subluxation complex.

INDEX TERMS: (MeSH): SKIN TEMPERATURE; DIAGNOSIS, COMPUTER-ASSISTED; INSTRUMENTATION; THERMOGRAPHY; CHIROPRACTIC; AUSTRALIA.

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INTRODUCTION

Chiropractic instrumentation has been described by Kyneur and Bolton as "the use of electrical devices applied to the spine for the purpose of determining the presence of vertebral subluxation."[1] One such instrument, introduced as the Neurocalometer (NCM) in 1924,[2] has evolved into the Nervo Scope (NS),[3] which today may be used within the Gonstead system of chiropractic analysis as an adjunctive diagnostic instrument contributing, in part, to a chiropractic diagnosis by "aiding in the location of neurologic dysfunction."[4] The validity and reliability of the NS, however, remain in question.[5,6]

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The NS consists of two groups of thermocouples in series with a micro voltmeter. Newer instruments include an amplifier to increase the range of sensitivity. Deflection of the voltmeter needle is such that it points towards the detector receiving the greatest amount of heat,[7] or away from the detector receiving least heat. It is operated by placing the detector probes on the skin either side of the spine and moving the instrument up or down with firm pressure. A level of interest is identified when the pointer deflects and returns to or near its original position within a very short vertical distance being travelled along the spine. The size of the deflection of the pointer may have some significance in the recording of a positive finding. The NS and its derivatives therefore measure paraspinal surface temperature differentials by the use of thermocoupled detectors and an analogue dial. As a temperature differential instrument it does not indicate absolute temperature.

Attempts to assess the validity of any clinical instrument face two hurdles, namely an adequate knowledge of the entity being measured and a known or "gold" standard against

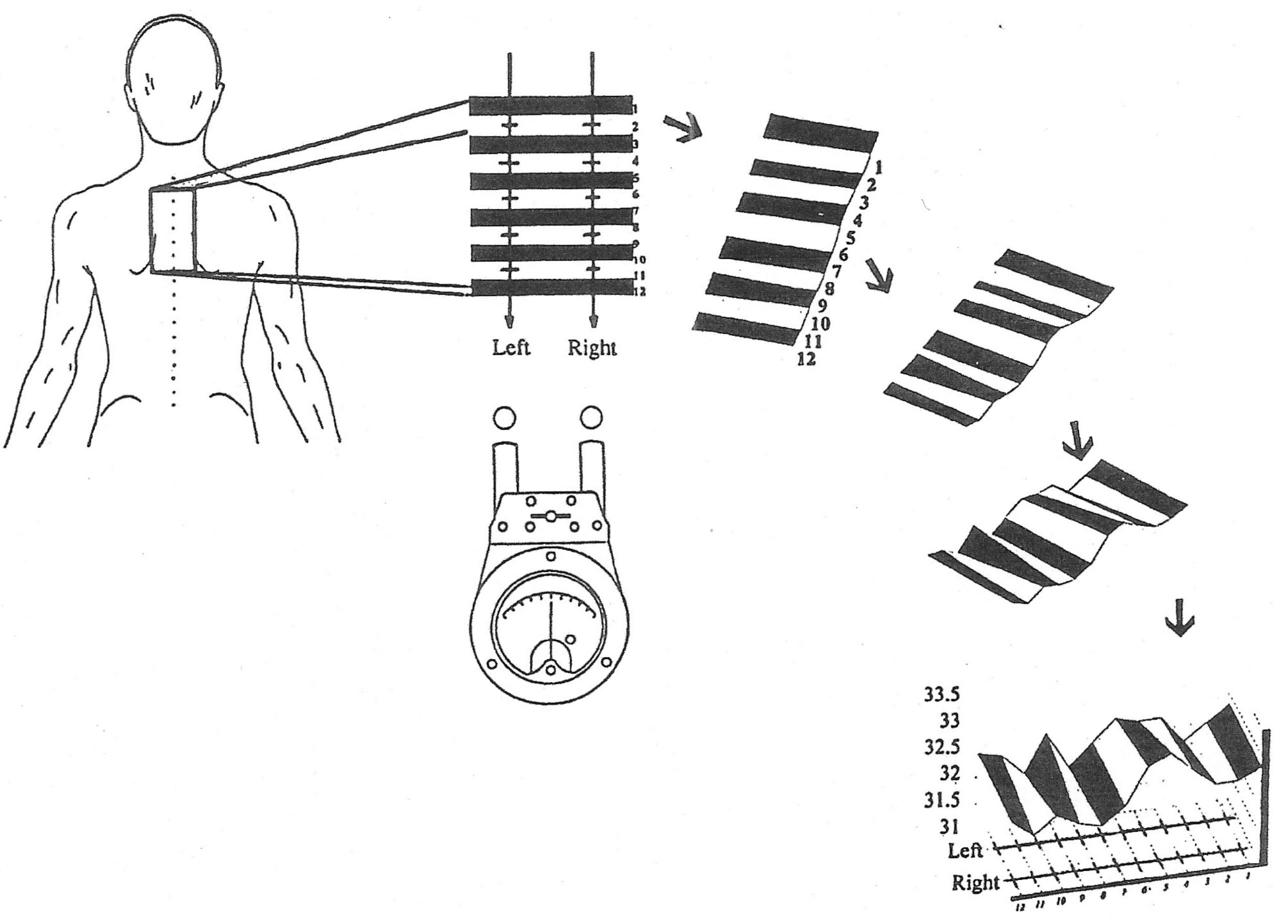

Figure 1. Typical schemata for point temperature collection and graph modelling.

which to judge the instrument under test.[8] There are deficits in both areas regarding the NS, as the literature has yet to adequately describe, in other than subjective terms, the entity of the "chiropractic subluxation" which the NS is claimed to help detect, and as a consequence, we lack any sort of objective characteristic to use as a gold standard.

The purpose of this study was to attempt to find a starting point for future descriptive analyses of the chiropractic subluxation. It was considered that such a starting point could be the generation of a thermal description of those areas of the spine identified by the NS as having a differential temperature reading. The spinal regions were elected to be those areas of the thoracic spine on which two blinded expert users of the NS agreed with respect to the presence of differential temperature, or to use the terminology of NS operators, a "break."

The thermal description was to be obtained by computer-assisted infrared thermography (CAIRT), a non-invasive imaging process able to generate temperature values for selected images of the spine. Most published reports indicate that thermal imaging is an accurate, sensitive method of determining cutaneous temperatures.[9] Further, the American Medical Association's Council on Scientific Affairs[10] reports that thermography may facilitate the determination of spinal root and peripheral nerve dysfunction and of spinal disorders, and may also be useful in documenting peripheral nerve and soft tissue injuries, such as muscle and ligament sprain/strain, inflammation, muscle spasm and myositis.

Thermography has been widely reported in the literature as being a useful indicator in the diagnosis of peripheral nerve injuries,[10-16] radiculopathies,[10,11,17-24] vertebral joint dysfunction,[25-28] reflex sympathetic dystrophy,[10,11,29,30] lumbar/low back pain,[17,20,31,32] headache,[33] myofascial pain syndromes,[10,11,34,35] deep venous thrombosis,[36,37] and spinal cord lesions.[10]

The investigating team felt it appropriate to use CAIRT to generate the thermal description of spinal levels identified by expert users of the NS, however we caution that this is an early attempt to meld contemporary technology with 70-year-old empirical beliefs. We also state categorically that this study is not to be read as any form of inter-examiner trial.

METHODS

The investigating team solicited 31 subjects from a late adolescent/young adult population. There were 18 males (mean age 23.61 yr) and 13 females (mean age 21.08 yr) who participated on one day under controlled conditions with informed consent. All subjects conformed to the standard protocols for infrared thermographic imaging, namely abstaining from smoking and exercise and being suitably gowned and stabilised prior to the readings.

An adhesive aluminium marker (visible on the infrared images) was placed over each of the C7 and L1 spinous processes of each subject. The inferior margin of the C7 marker was used as the datum point for measurement of observations. The first 5 cm of the spine was excluded to limit any potential local skin effects from either the adhesive marker or the mechanics of locating the measuring tape. The section of spine thus examined was typically about 15 cm, ranging from 5 cm below C7, to about 20 cm below C7.

Each subject was prepared and stabilised, and then first presented to the thermographer, where the image of their back was recorded on videotape and computer disc. The thermographic equipment used was a FLIR TVS Model 7300 Clinical Thermography unit, incorporating the Hughes Thermal Image Management System (TIMS) software. The subjects then presented in alternate order to each NS observer, who scanned the spine using a unit called the Skin Temperature Differential Instrument (STDI), manufactured by the Gonstead Clinical Studies Society (Australia) Limited, while an assistant recorded the observations. When a distinctive pattern was noted by the observer and deemed relevant, the assistant measured the distance of that event from the inferior margin of the C7 spinous marker.

The total distance between the two spinal markers was recorded at the time the thermographic image was captured (with the subject seated), and conveyed with each subject as they attended for each NS reading in order to replicate the same seated posture at each of these readings (indicated by duplicating the inter-marker distance). A spinal level was selected for thermal analysis when the measured point of one observer's found effect was within 2.0 cm of the effect found by the other observer. These represented one level from each of five subjects, ranging between 12.4 cm and 16.0 cm caudad to the C7 marker (clinically about the mid-thoracic level).

The thermal description of each level was obtained through retrospective analysis of the stored computerised images. The measured level was termed the "area of interest" (AOI), and a box about 3.75 cm high by about 9.0 cm wide was drawn around it within the image-processing software. Two parallel series of point temperatures in degrees Celsius (°C) were then taken, both commencing above the AOI and ending within the AOI near its inferior border, representing the caudal track of the Nervo Scope. The two vertical tracks were spaced about 5 cm apart to represent the left and right sensors of the instrument. The temperature was sampled at 12 points along each line, covering a vertical distance of about 7 or 8 cm and providing a point temperature at about 0.5 cm intervals. This interval matches the diameter of the sensor, thus providing a series of non-overlapping point temperatures. Point 1 was most cephalad and point 12, most caudad. A representation of how the 3-D graph model was generated from this procedure is shown in Figure 1.

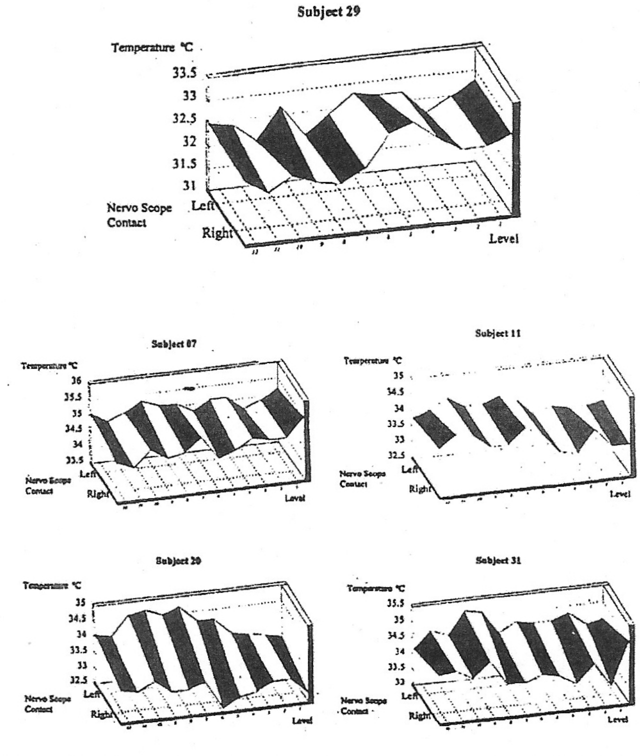

Figure 2. Three-dimensional graph modelling of paraspinal temperatures by subject.

The temperature readings therefore represent the left and right temperatures, sampled about each 0.5 cm, leading into and through the AOI. A number of analyses were conducted on the stored images, including the construction of isotherms and line profiles, however the multiple point method was selected as providing the most appropriate data for the creation of the 3-D graph models (Figure 2).

Each graph model can be considered as representing a "slice of skin" with a length of about 8 cm lying along the X axis and a width of about 5 cm along the Z axis, with temperature shown on the Y axis. Even though the mean temperatures varied between 32.48° and 35.02°C across subjects, the Y axis is shown with a constant 2.5° window.

A second style of graph is used to depict resultant data from this study in order to explore characteristics of the point temperature series beyond simple left/right asymmetry. This graph is a circular or "radar" plot, and reflects the dynamic nature of contact thermocouple assessment, where the concentric rings indicate the size and polarity of the change in °C between one level and the next for the left and right series of point temperatures on each subject (Figure 3). A positive direction indicates the temperature increased as the sensor moved caudad from one point to the next; conversely, a negative value indicates that the temperature fell.

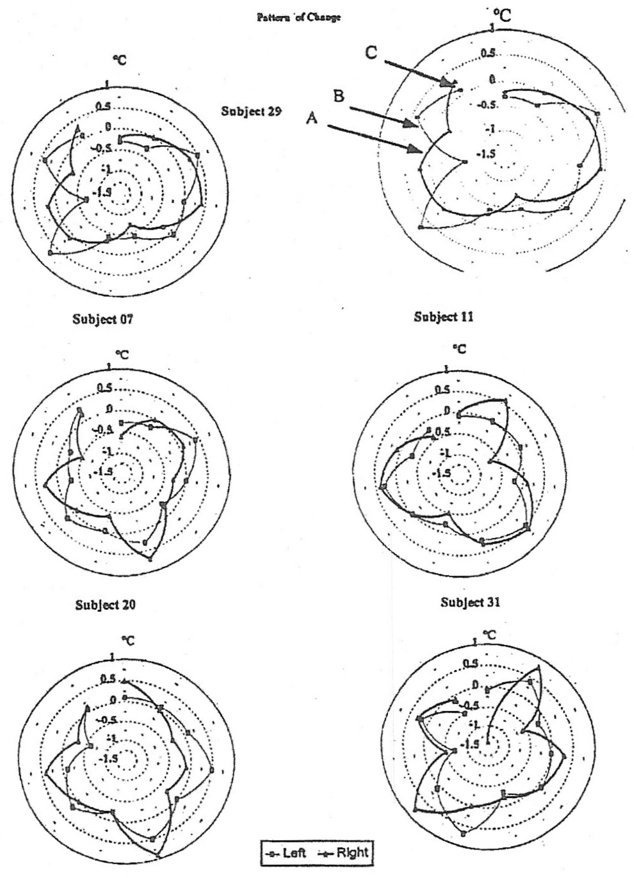

Figure 3. The pattern of temperature change by subject.

RESULTS

Five separate spinal levels are described in the data of this report. The thermal description given for each subject includes:

(i) a series of point temperatures taken at about 0.5 cm intervals in a vertical paraspinal line both to the left and right of the spine (shown pictorially in the graphs of Figure 2 and in Table 1),

(ii) descriptive statistics of the point temperatures (Table 2),

(iii) the temperature difference between the left and right point reading at each of the 12 point levels measured (Table 3),

(iv) the temperature difference between the successive levels on each side (Table 4), and

(v) a dynamic circular graph (Figure 3) of the values reported in Table 4.

The series of point temperatures demonstrate a relatively stable thermal situation in the selected regions on each subject. The mean left and right temperatures of all subjects fell within 2.54°C of each other (Table 2). Similarly both the *minima* and *maxima* were within a 2.7°C range across all these five subjects. The smallest range for any one series was 0.6°C (subject 07, left series), and the greatest was 1.4°C (subject 31, right series) (Table 2).

From the descriptive statistics reported in Table 2, the mean value of the differences between the mean of the left series and the mean of the right series for all subjects is also shown to be quite small, at 0.308°C (mean range 0.05 to 0.88°C). At various levels the individual left/right difference was as great as 1.6°C in one subject (subject 20, point 6, Table 3), however this subject presented with a clearly identifiable left thermal asymmetry indicative of a trigger point. The remaining subjects exhibited a left/right difference no greater than 1.1°C at any one level (Subject 31, point 8, Table 3), and typically less than half a degree (mean = 0.296°C). The temperature difference between successive levels (Table 4) was similarly small, the mean of the means being 0.2955°C (median 0.277°C, Q1 = 0.2273, Q3 = 0.3409°C).

DISCUSSION

The use of the NS within chiropractic clinical practice is described in ambivalent terms by contemporary authors,[4] however earlier writers were more incisive, clearly stating, "...chiropractic instrumentation...will show whether or not subluxations exist..."[7] The NS has been described as identifying the temperature differential or the "warmer side" of the spine,[38] and the principles applied by Gonstead describe heat as radiating away from the area of tissue damage in acute subluxation and towards the area of compression in chronic subluxation,[7] thus reinforcing the simplistic concept of a left/right temperature differential at a specific spinal level. However from an empirical point of view, a "hot reading" may just as likely be due to a dramatic decrease in microvascular circulation on the side opposite the "break" as to an increase on the side of the "break" (Hart C, personal communication, 1994).

The three-dimensional graphs support the empirical concept of a left/right temperature differential at a certain level by depicting a model of the skin temperature in the region of a "break" as determined by two experienced NS operators. With reference to the graph for Subject 29 (Figure 2), the model shows symmetrical temperatures at the start of the sampling (level 1), falling to level 3, then rising to be higher on the right at level 5, a fall on both sides to level 8, then a sharper rise on the left at level 9, a slower rise on the right at level 10 while the left is falling, then about equal temperatures at the end of sampling (level 12).

This pattern appears to be evident in each of the five models, namely an asymmetrical peak following a segment of thermal symmetry, however subject 11 shows an earlier asymmetry (right level 3), and subject 20 shows a more consistent asymmetry over several levels, corresponding with a larger area of thermal asymmetry evident on the original thermograph. These constructs from found data therefore fit the theoretical construct of subluxation being attended by thermal asymmetry, however the question now becomes

Table 1

POINT TEMPERATURE BY SUBJECT

LEVEL	SUBJECT NUMBER									
	07		11		20		29		31	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
1	35.2	35.5	33.7	33.5	33.4	32.8	32.8	32.8	34.5	35.0
2	34.9	34.9	33.6	33.5	33.5	33.3	32.5	32.6	34.4	33.6
3	34.7	34.9	33.6	34.1	33.6	33.3	32.2	32.6	34.8	34.4
4	35.1	35.0	33.7	33.4	33.7	33.0	32.7	32.9	34.6	33.8
5	35.1	34.7	33.5	33.5	34.2	32.9	32.7	33.3	34.6	34.1
6	34.8	34.5	34.0	34.1	34.2	32.6	32.8	33.1	34.7	34.2
7	35.1	35.2	34.2	34.4	34.7	33.5	32.4	32.4	34.4	34.0
8	35.1	34.8	34.0	33.9	34.5	33.3	32.0	32.1	35.1	34.0
9	35.3	34.7	34.0	33.9	34.7	33.3	32.7	32.2	35.2	34.8
10	35.0	35.0	34.3	34.3	34.6	33.7	32.0	32.4	34.5	34.3
11	34.8	34.5	34.0	34.4	34.0	33.4	32.4	32.1	34.7	34.6
12	35.1	34.7	33.8	34.0	34.1	33.5	32.5	32.4	34.2	34.5

T = +C

Table 2

DESCRIPTION OF TEMPERATURE BY SUBJECT

	SUBJECT NUMBER									
	07		11		20		29		31	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Mean	35.02	34.87	33.87	33.92	34.10	33.22	32.48	32.58	34.64	34.28
SE	0.05	0.08	0.07	0.11	0.14	0.09	0.08	0.11	0.08	0.12
Median	35.10	34.85	33.90	33.95	34.15	33.30	32.50	32.50	34.60	34.25
SD	0.18	0.29	0.25	0.37	0.47	0.32	0.29	0.39	0.29	0.41
Min	34.7	34.5	33.5	33.4	33.4	32.6	32.0	32.1	34.2	33.6
Max	35.3	35.5	34.3	34.4	34.7	33.7	32.8	33.3	35.2	35.0
Range	0.6	1.0	0.8	1.0	1.3	1.1	0.8	1.2	1.0	1.4

T = +C

whether it is simply these levels of asymmetry which are detected by the NS and hence considered indicative of "subluxation." If so, any thermal imaging instrument should be capable of identifying left/right asymmetry and hence, in the view of some practitioners, the subluxation complex.

The data from this study seem to indicate that there is a greater complexity in the thermal characteristics of what may be the subluxation complex than previously thought. For example, the left/right temperature differences are essentially very small, being typically less than half a degree. It is reasonable to question whether the sensitivity of the NS/operator combination (especially with the earliest versions of the NS, as opposed to the later models with amplification) is such that it would reliably detect such small differences. It must be understood that clinically, the NS is used in a dynamic mode, being "glided" over the skin by the operator, thus introducing, as Triano described, a difficulty in standardising pressure and angle of probe contact between operators.[38]

Table 3

TEMPERATURE DIFFERENCE (LEFT-RIGHT) AT EACH LEVEL BY SUBJECT

LEVEL	SUBJECT NUMBER				
	07 Left-right	11 Left-right	20 Left-right	29 Left-right	31 Left-right
1	-0.3	0.2	0.6	0.0	-0.5
2	0.0	0.1	0.2	-0.1	0.8
3	-0.2	-0.5	0.3	-0.4	0.4
4	0.1	0.3	0.7	-0.2	0.8
5	0.4	0.0	1.3	-0.6	0.5
6	0.3	-0.1	1.6	-0.3	0.5
7	-0.1	-0.2	1.2	0.0	0.4
8	0.3	0.1	1.2	-0.1	1.1
9	0.6	0.1	1.4	0.5	0.4
10	0.0	0.0	0.9	-0.4	0.2
11	0.3	-0.4	0.6	0.3	0.1
12	0.4	-0.2	0.6	0.1	-0.3

T = +C

Table 4

TEMPERATURE DIFFERENCE BETWEEN SUCCESSIVE LEVELS BY SUBJECT

LEVEL	SUBJECT NUMBER									
	07		11		20		29		31	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
2-1	-0.3	-0.6	-0.1	0.0	0.1	0.5	-0.3	-0.2	-0.1	-1.4
3-2	-0.2	0.0	0.0	0.6	0.1	0.0	-0.3	0.0	0.4	0.8
4-3	0.4	0.1	0.1	-0.7	0.1	-0.3	0.5	0.3	-0.2	-0.6
5-4	0.0	-0.3	-0.2	0.1	0.5	-0.1	0.0	0.4	0.0	0.3
6-5	-0.3	-0.2	0.5	0.6	0.0	-0.3	0.1	-0.2	0.1	0.1
7-6	0.3	0.7	0.2	0.3	0.5	0.9	-0.4	-0.7	-0.3	-0.2
8-7	0.0	-0.4	-0.2	-0.5	-0.2	-0.2	-0.4	-0.3	0.7	0.0
9-8	0.2	-0.1	0.0	0.0	0.2	0.0	0.7	0.1	0.1	0.8
10-9	-0.3	0.3	0.3	0.4	-0.1	0.4	-0.7	0.2	-0.7	-0.5
11-10	-0.2	-0.5	-0.3	0.1	-0.6	-0.3	0.4	-0.3	0.2	0.3
12-11	0.3	0.2	-0.2	-0.4	0.1	0.1	0.1	0.3	-0.1	-0.4

T = +C

Further, the dynamic movement of the sensors along a glide path means that the instrument is responding to any segmental left/right asymmetry after being conditioned by the preceding temperature on each side. In other words, the NS may not show thermal asymmetry if held against the skin in a static manner, but may detect asymmetry through a comparison of the *rate of thermal change* on one side compared with the rate of change on the other.

Support for this concept is found in the radar graphs which demonstrate the size and nature (rising or falling) of the difference between sequential temperatures at each level on each side of the spine. The graphs as presented in this paper therefore demonstrate what may come to be acknowledged as a characteristic of the spinal level detected by the NS, namely that while the temperature is changing in one direction on one side, it is varying in the opposite direction on the other side.

For example, Figure 3 includes an enlargement of a part of the radar plot for subject 29. Arrow A indicates the right-side temperature was falling by 0.5° (from a between-point value of +0.2° generated by the rise from 32.2° at point 9 to 32.4° at point 10, to a between-point value of -0.3° generated by the fall from 32.4° at point 10 to 32.1° at point 11), while Arrow B indicates the left-side temperature was rising by 1.1° (from a between-point value of -0.7° generated by the fall from 32.7° at point 9 to 32.0° at point 10, to a between-point value of +0.4° generated by the rise from 32.0° at point 10 to 32.4° at point 11). The left side then fell again, while the right side increased to a point of approximate symmetry (arrow C). This effect is more complex than the simple left/right asymmetry which is depicted in the 3-D model for subject 20, and is dependent on the dynamics of sensor movement.

If the observations found in this study are valid, then it may be that we need also to consider the thermal changes which fall in a linear manner parallel to the spine as well as the traditionally considered left/right asymmetry at segmental levels. The data from this study demonstrate that the paraspinal temperature varies symmetrically within a very small range (< 0.5°C) in certain spinal regions, and at a particular level will vary asymmetrically, with one side falling while the other side increases. This effect has been shown in the radar plots for each of the five subjects, namely subject 07 at 9 o'clock, subject 11 at 2 o'clock, subject 20 at 8 o'clock, subject 29 at 10 o'clock, and subject 30 at 7 o'clock (clock positions given with reference to Figure 3). The plot for subject 20 does not strongly exhibit this crossover characteristic, however this is the subject with the objective evidence of a localised heat source on the left at these levels, which could act as a confounder.

These data give rise to an alternate hypothesis which states, "The spinal region to which the contact thermoscope is sensitive is that region where an asymmetrical thermal dynamic exists between the paraspinal temperature gradients." If this study is replicated and the hypothesis supported, it will present us with an objective dimension which may well be a parameter of the subluxation complex, given the empirical use of the NS to assess the spine for evidence supportive of the need for chiropractic adjustment. Further, if we can identify such an objective dimension, then we can more fully investigate why clinical instruments such as the NS do not have stronger concordance (fair as incidentally noted in this study, but substantial as found by Plaugher *et al.* in a comparable spinal region[5]).

It may be that CAIRT could gain greater utility in chiropractic practice if it can be used in a way to more easily identify these objective characteristics. This could be done by obtaining a line profile of the skin temperature along either side of the spine, generating the progressive thermal differential values and then, by overlapping the two data sets, identifying levels where the asymmetrical thermal dynamic existed. This is an area for future study in our chiropractic laboratories at RMIT.

CONCLUSION

This study of 31 subjects identified five subjects where two blinded, experienced operators of a traditional chiropractic instrument, the NS, agreed there was appropriate evidence of spinal dysfunction at a particular spinal level. A description of these five levels was generated by CAIRT and the data plotted in a series of graph models. A particular characteristic was found, namely that an asymmetrical thermal dynamic existed between the paraspinal temperature gradients at these levels, meaning that the skin temperature varied asymmetrically, with one side falling while the other side increased. These events happen within a relatively small window, as the thermal description of these spinal levels revealed a left/right difference of typically about 0.3°C and no greater than 1.1°C, and a series range on any one side of the spine of typically 1.0°C and no greater than 1.4°C.

The radar plots of the data clearly demonstrate the presence of an asymmetrical thermal dynamic which may, if replicated in other laboratories, represent an objective dimension of spinal dysfunction, or in more common terms, the subluxation complex. If this objective dimension can be reliably and repeatedly identified, we will have evidence in support of the validity of the contact thermocouple in chiropractic clinical practice. Alone, this study can be read as demonstrating that the clinical entity found by use of the NS exhibits more than simply a left/right thermal asymmetry.

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