ORIGINAL RESEARCH

Changes in Digital Skin Temperature, Surface Electromyography, and Electrodermal Activity in Subjects Receiving Network Spinal Analysis Care

Eric B. Miller, Ph.D., Peter D. Redmond, D.C.

Abstract — A preliminary study was conducted to evaluate changes in digital skin temperature (DST), surface electromyography (sEMG), and electrodermal activity (EDA) in a group of twenty subjects receiving Network Spinal Analysis (NSA) care. Data, simultaneously derived from all three parameters, were considered to be indirect correlates of sympathetic nervous system activity. Subjects, including a group of five controls, were assessed for a period of 17 minutes. The continuous assessment period included a baseline interval of 4.5 minutes, followed by a 12.5 minute period which was divided into five 2.5 minute intervals. Care was administered to the NSA recipient group immediately after the baseline period, whereas controls received no intervention following baseline. Results revealed no significant differences in DST either within or between the two groups. Surface EMG readings were relatively constant over the five intervals following baseline in the NSA group, while controls showed significant ($p < 0.05$) increases in sEMG at the second through fifth intervals relative to the first interval following baseline activity. Electrodermal activity was significantly decreased ($p < 0.01$) in the NSA group in the second through fifth intervals compared to baseline. Moreover, decreases varied between intervals, but exhibited a leveling from the third through fifth interval. Control subjects, alternatively, exhibited an increase in EDA in all intervals following baseline. The extent of increase resulted in EDA activity significantly greater than the NSA group at the third through fifth intervals. It was concluded that the increase in EMG activity in the control groups may have reflected an increasing level of anxiety due to the duration of the recording period. Since the NSA group expressed constancy in sEMG activity during the same period, coupled to significant decreases in EDA, a "sympathetic quieting effect" was postulated to occur in subjects receiving NSA care. This conclusion is consistent with hypothesized neurological pathways linked to responses observed during NSA care, as well as other reports of self-reported improvements in mental/emotional state and stress reduction in patients receiving Network Chiropractic Care.

Key words: Network Spinal Analysis, vertebral subluxation, sympathetic nervous system digital skin temperature, surface electromyography, electrodermal activity.

Introduction

While one of the primary objectives of Network Spinal Analysis (NSA) is correction of vertebral subluxation,[1] recent study regarding Network Chiropractic, now practiced as Network Spinal Analysis (NSA), has provided evidence of enhanced self-reported "wellness" benefits.[2] Through retrospective recall, recipients assessed a spectrum of health related measures, including the ability to cope with stress, before as compared to their present experience under Network care. Although results from this provocative study of Network Care support anecdotal reports concerning its positive outcomes, it is important to demonstrate if such accounts are accompanied by physiological changes in NSA recipients.

While these survey results suggest that positive changes occur in association with this form of care, questions regarding the biological mechanisms promoting these changes are yet to be resolved. However, it stands to reason that generalized improvements in health which involve positive coping with stress could be a reflection of reduced sympathetic nervous system activity.[3-5] If, indeed this is the case, the research hypothesis is proposed that changes indicative of decreased sympathetic activity should be demonstrable concomitant with NSA care.

Measurements are available for such an assessment. Early observations of changes in electrical activity of the skin in

Address reprint requests to: Dr. Eric B. Miller, 125 Prospect St. Phoenixville, PA 19460

response to various physical and emotional stimuli were made by the French Neurologist, Charles Fere[6] and the Russian physiologist, Tarchanoff.[7] Although both were measuring electrodermal activity (EDA), their approaches were different in that Fere measured the flow of an externally applied current between two skin electrodes, while Tarchanoff measured the difference in electrical potential between two skin areas. Both, however, recorded their findings as galvanometric deflections. Hence the measurement of EDA became known among early researchers as galvanic skin response (GSR).[7] Fere believed that the changes in EDA following sensory and emotional stimuli were indications of nervous system excitation, or "arousal."

Although its physiological basis has yet to be thoroughly resolved, investigation suggests that EDA is the product of changes in sweat gland activity.[8,9] Sweat glands, while widely distributed in the skin , appear to serve different functions based on their type and location. Apocrine sweat glands which are closely associated with hair follicles, are believed to principally serve in thermoregulation.[10] Eccrine glands, however, which are predominantly found in the palms and soles of the feet are believed to be associated with sympathetic activity due to their profuse sympathetic innervation. Study has shown an association between putative sympathetic outflow and eccrine activity, with increased activity noted particularly in the palms and fingers in situations that were emotionally arousing.[11]

Additionally, DST[20] and sEMG (through biofeedback)[12-17] have also been shown to be associated with changes in sympathetic output. Based on information which links EDA, DST, and sEMG to varying levels of sympathetic outflow, the present study focused on recording changes in these parameters before and during the clinical application of NSA. The information was collected with the intention of investigating the relationship between improved ability to cope with stress, reported in NSA recipients, and physiological changes evoked through the sympathetic nervous system.

Methods

Subjects and Study Setting

This initial study was designed as a preliminary investigation to compare patients' baseline DST, sEMG, and EDA to changes which might occur during the administration of NSA. Twenty subjects, all of whom were regular recipients of NSA for a minimum of 3 months, were selected for this study. The study population consisted of 16 females and 4 males, ranging in age from to 20 - 54 years of age (mean 40.0 ± 10.0, median, 43.0 years). Inclusion criteria were: (1) Patients 18 years or older, (2) Patients who had attained a level of response to NSA indicating the ability to engage both the respiratory and somatopsychic waves,[1,2] and (3) patients with no chronic pain syndromes or other conditions which would create a chronic state of anxiety or stress.[29] The significance of the somatopsychic and respiratory waves, as well as the methods and clinical objects of NSA care are described elsewhere.[1,12] The nature of the present study was explained to each individual, and written consent to participate was obtained. The investigation was conducted in the private office setting at the West Chester and Philadelphia locations of the South Street Healing Center, in Pennsylvania between the months of January and March, 1997.

Physiological Measurements

Electrodermal activity, was determined in the form of digital skin conductance employing a J & J i330 physiological monitoring system, interface and modules (J&J Engineering, Inc., Poulsbo, WA). In order to record skin temperature and skin conductance simultaneously, two temperature/ electro- dermograph T-601 modules were used, one for measuring temperature, the other for conductance. One unit incorporated a thermistor probe (TS-600) capable of measuring changes as small as 0.006 degrees Fahrenheit, while the other utilized an EDG silver/silver chloride electrode cable harness (CH-600) capable of measuring changes as small as 0.01micromho.

The measurement of EDA was determined by application of two finger electrodes (SE-35). Prior to placement, a small amount of conductivity gel (Signa ECG electrolyte cream # 17-05) was placed on each circular electrode which was attached to a velcro strip with a snap fastener. The electrode assembly was then snapped securely to the first pad (most proximal) of the left index and ring fingers. The tip of the finger was avoided in order to reduce the probability of contact artifact. Prior to the study, the constant voltage (0.166 VDC, 0 to 50 micromhos) EDG was calibrated to 20.0 ± 0.3 micromhos, with a factory calibration board.

Digital skin temperature was determined by attaching the thermistor probe to the dorsal surface, just after the fingernail, of the left middle finger with dermacell-type (porous) paper tape. The thermistor was placed in the center (both length and width) of one piece of tape, and then placed on the finger so that the thermal cable ran downwards toward the wrist. The paper tape was used to secure the thermistor to the finger snugly, but so tight as to have the patient perceive their pulse-beat. Prior to the study, the T-601 module (range of detection between 60 - 100 degrees F) was calibrated with a standard thermometer with a 0.1 degree F resolution, or against the other T-601 module.

Surface electromyography was monitored with a EMG 501 module which employed two surface silver-silver chloride electrodes making contact with Signa electrolyte conductive cream (no. 17-05), and one ground (Thought Technology, Montreal, Quebec, no. miep 02-000). The two electrodes were placed on each side of the spine at the level of the sixth thoracic vertebra. This configuration generated microvolt data in the bandpass region of 100 - 200 Hz. The microvolt data, indicative of muscle activity in that region, was summed rather than being reported unilaterally. The cable from the electrodes was allowed some slack and then taped or clipped to the subject's clothing to avoid a "pull effect" on the sensors which could affect the readings.

Study Design

An initial baseline measurement for EDR, DST, and sEMG was continuously recorded for each subject for a period of 4.5 minutes. Although subjects were in the room for approximately 10 minutes prior to the recording period, the baseline period further allowed subjects to equilibrate to the nearly constant

ambient room temperature (between 23 - 26 degrees C) and normal room sounds, including soft background music, inherent to the study environment.

Immediately following the 4.5 minute baseline measurement period, continuous readings of the same three parameters were recorded for an additional 12.5 minutes. Attention was given to maintaining a relatively constant room temperature (between 23-26 degrees C) to avoid a "sweat response" which would be expected to effect the parameters being studied. The total period was divided into five intervals of 2.5 minutes each for ease of analysis which also permitted comparison between the baseline period, during which subjects were seated, and subsequent intervals during when each subject was prone. This resulted in a cumulative recording period, including baseline, of 17.0 minutes. The administration of appropriate spinal contacts, as part of the NSA protocol, commenced immediately following the acquisition of baseline data. Baseline data was acquired with subjects in the seated position. Immediately following the baseline period, each subject was positioned in the prone position. The practitioner's table is designed with a longitudinal opening to allow the nose and mouth to receive air, while permitting the face to be flush to the table top. This prevents undue stress to the head and neck area while the subject is in the prone position.

In the absence of any intervention, values would be expected to change over the baseline period, and the subsequent five intervals. To assess the extent of change, five subjects, under NSA care, were selected from the first five interviewees meeting the selection criteria. These subjects served as controls receiving no NSA intervention during the measurement period. These subjects, four females and one male, ranging in age from 37 - 40 years (mean, 44.0 ± 8.0, median, 40 years) were monitored over the entire baseline period, plus five subsequent intervals. The

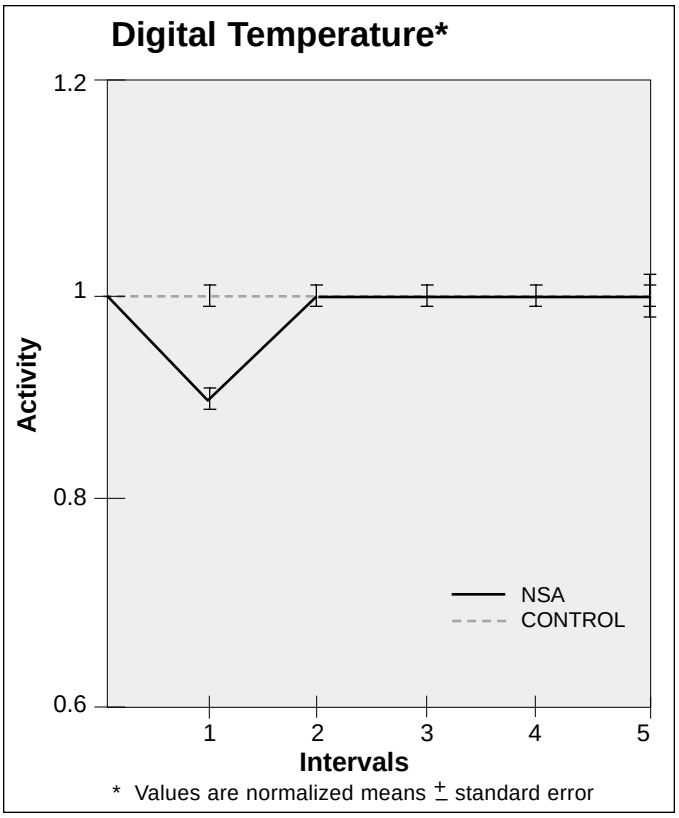
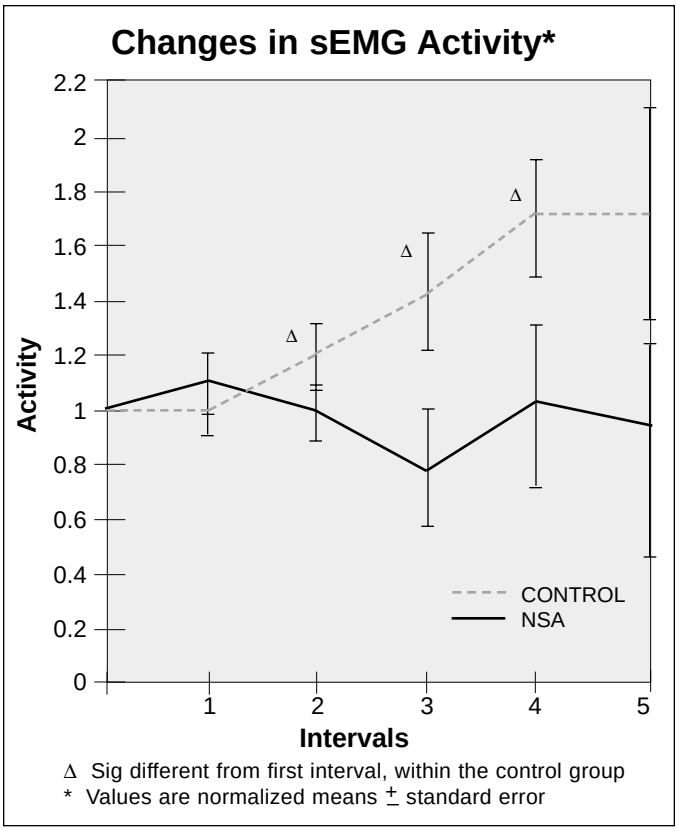


Table 1. Digital Temperature* in Controls and Subjects Receiving a Time Course of Network Spinal Analysis Care.

		Time Course of Care				
Interval	Baseline	1	2	3	4	5
Elapsed Time (min)	(0-4.5)	(4.5-7.0)	(7.0-9.5)	(9.5-12.0)	(12.0-14.5)	(14.5-17.0)
NSA						
TEMP (F ± s)	83.8 ± 6.4	83.1 ± 7.9	83.4 ± 7.3	83.6 ± 7.6	84.0 ± 7.3	84.3 ± 7.4
Std. Error	± 1.43	± 1.77	± 1.13	± 1.70	± 1.63	± 1.66
TEMP (F ± s)	1.0	0.9 ± 0.04	1.0 ± 0.03	1.0 ± 0.04	1.0 ± 0.05	1.0 ± 0.06
Std. Error		± 0.01	± 0.01	± 0.01	± 0.01	± 0.01
Controls						
TEMP (F ± s)	85.8 ± 1.9	87.3 ± 2.5	87.9 ± 2.0	88.4 ± 1.8	88.0 ± 1.9	87.1 ± 1.9
Std. Error	± 0.84	± 1.12	± 0.89	± 0.80	± 0.85	± 0.85
TEMP (F ± s)	1.0	1.0 ± 0.02	1.0 ± 0.02	1.0 ± 0.03	1.0 ± 0.03	1.0 ± 0.04
Std. Error		± 0.01	± 0.01	± 0.01	± 0.01	± 0.02

* Temperature is expressed in degrees Fahrenheit (F).



methods of patient placement and instrument recording were exactly as that administered to the group receiving NSA care.

Light Touch Contact Points During NSA Care

Throughout the course of the study, during which time NSA was administered to each subject, various light touch contacts were made to specific regions of the spine, based on the established protocol described elsewhere.[1,18] The anatomical landmarks contacted involved one or more of the following: the occiput (0X), atlas vertebra (C1), axis vertebra (C2), fifth cervical vertebra (C5), right post sacral iliac (PSIR), left post sacral iliac (LSIR), medial left sacral base left (MLSB), medial right sacral base (MRSB), bilateral sacral base (BSB), tip of coccyx (TC), right coccyx (RC), left coccyx (LC). Since the subluxation status of each patient was unique, the sequence and number of tissue contacts thus varied accordingly.

Analysis of Data

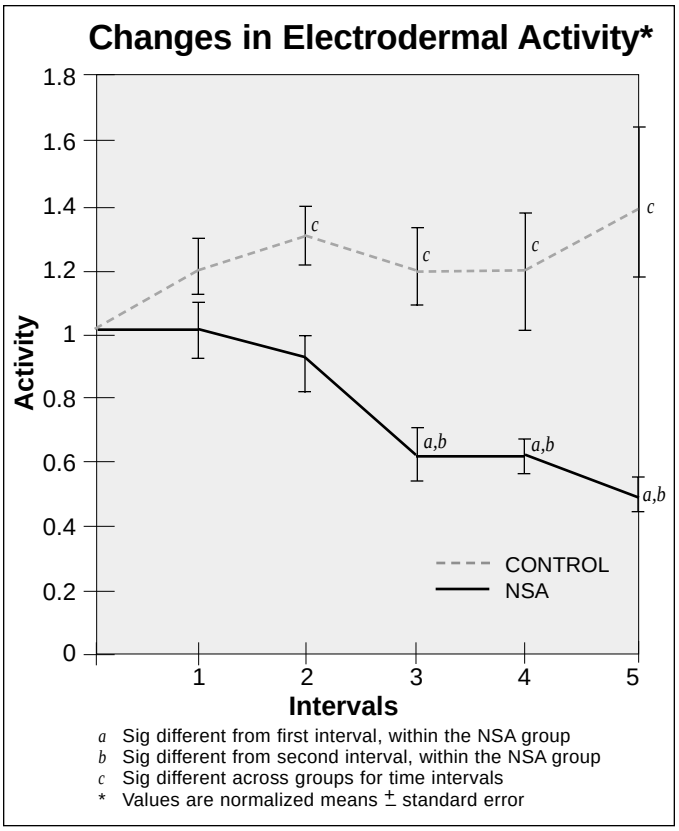
Data derived from the measurement of EDA, DST, and sEMG were evaluated for both the control group and NSA care recipients as a time series. Since absolute values varied between individuals, all values were also normalized by dividing by the baseline value, then averaged. Thus, for these three parameters (considering both absolute values and normalized values) each

Table 2. Changes in Surface Electromyography (sEMG) Activity in Controls and Subjects Receiving a Time Course of Network Spinal Analysis Care.

		Time Course of Care				
Interval	Baseline	1	2	3	4	5
Elapsed Time (min)	(0-4.5)	(4.5-7.0)	(7.0-9.5)	(9.5-12.0)	(12.0-14.5)	(14.5-17.0)
NSA						
sEMG Activity ± s (microvolts)	3.5 ± 1.0	3.6 ± 2.2	3.1 ± 1.7	2.6 ± 3.5	3.1 ± 4.9	2.9 ± 5.5
Std. Error	± 0.22	± 0.49	± 0.38	± 0.78	± 0.10	± 1.23
sEMG Activity ± s (normalized)	1.0	1.1 ± 0.6	1.0 ± 0.4	0.8 ± 1.1	1.0 ± 1.5	0.9 ± 1.7
Std. Error		± 0.11	± 0.09	± 0.25	± 0.34	± 0.38
Controls						
sEMG Activity ± s (microvolts)	8.5 ± 5.4	5.4 ± 6.9	11.7 ± 9.8	15.3 ± 12.8	14.7 ± 12.1	16.4 ± 16.4
Std. Error	± 2.41	± 3.10	± 4.38	± 5.71	± 5.40	± 7.32
sEMG Activity ± s (normalized)	1.0	1.0 ± 0.2	1.2 ± 0.3†	1.5 ± 0.5†	1.7 ± 0.5†	1.7 ± 0.8
Std. Error		± 0.09	± 0.13	± 0.22	± 0.22	± 0.36

† Significant difference from the first time interval, within the control group (Results for p values).

of the five post baseline intervals were compared to their respective baseline, and subsequently to each prior interval, by a paired two-tailed T-test, $p < 0.01$. Additionally, NSA care recipient data (absolute data as well as normalized values) were compared to control data, using the same approach as described above. In this instance, data was analyzed by an independent two-tailed T-test. A larger alpha of 0.05 was used when comparing sEMG normalized data since the large standard deviations observed were expected to preclude significant differences at an alpha of 0.01. The F test was employed to determine if the two samples reflected equal or unequal variances. For graphic comparisons normalized data were expressed as mean ± standard error to demonstrate the variance around the respective mean values.



Results

Digital (Peripheral) Skin Temperature

Digital skin temperature (Table 1, Figure 1), for NSA care recipients varied between 83.1 ± 7.9 to 84.3 ± 7.4 degrees Fahrenheit (28.4 to 29.1 degrees centigrade). Controls ranged from 85.8 ± 1.9 to 88.4 ± 1.8 degrees Fahrenheit (29.9 to 31.3 degrees centigrade). Comparison of absolute temperatures within the control group and the NSA recipient group revealed no significant differences between any of the time intervals, nor when the five intervals were compared to baseline. Moreover,

Table 3. Changes in Electrodermal Activity (EDA) in Controls and Subjects Receiving a Time Course of Network Spinal Analysis Care.

		Time Course of Care				
Interval	Baseline	1	2	3	4	5
Elapsed Time (min)	(0-4.5)	(4.5-7.0)	(7.0-9.5)	(9.5-12.0)	(12.0-14.5)	(14.5-17.0)
NSA						
EDA (umhos ± s)	6.1 ± 4.4	6.3 ± 4.5	5.2 ± 4.0‡	3.8 ± 3.5†‡^	3.4 ± 3.1†‡^	3.1 ± 2.7†‡^
Std. Error	± 0.05	± 0.05	± 0.20	± 0.5)	± 0.60	± 0.70
EDA (normalized)	1.0	1.0 ± 0.4	0.9 ± 0.4	0.6 ± 0.4‡^	0.6 ± 0.3‡^	0.5 ± 0.4‡^
Std. Error		± 0.09	± 0.09	± 0.09	± 0.07	± 0.09
Controls						
EDA (umhos ± s)	2.4 ± 1.9	2.7 ± 2.2	2.9 ± 2.4	2.9 ± 2.6	2.9 ± 2.7	3.2 ± 3.0
Std. Error	± 0.85	± 0.98	± 1.07	± 1.16	± 1.20	± 1.34
EDA (normalized)	1.0	1.2 ± 0.2	1.3 ± 0.2	1.2 ± 0.31[1]	1.2 ± 0.41[1]	1.4 ± 0.51[1]
Std. Error		± 0.09	± 0.09	± 0.13	± 0.18	± 0.22

† Significant difference from baseline, within the group (Results for p values).
‡ Significant difference from the first interval, within the group (Results for p values).
^ Significant difference from the second interval, within the group (Results for p values).
1 Significant difference across groups (controls - NSA recipient group, (Results for p values).

when the normalized values were compared, no significant differences were observed either within groups or between the groups. It appeared as though fluctuations recorded in both groups represented normal distribution. The values obtained were found to be within the range of normative skin values for the dorsum of the foot (29.7 - 35.4 degrees centigrade), reported by Uematsu et al (1988),[19] and the hand, as reported by Arena and Hobbs (1995). [20]

Surface Electromyography

In regard to surface EMG readings, expressed as microvolts, mean values varied more within the control group than the NSA recipient group (Table 2). There were no statistically significant differences within the NSA recipient group when data was compared against the baseline or between the five intervals following baseline. Moreover, when data for the NSA recipient group was normalized to the baseline value, the changes over time were small (Table 2, Figure 2).

Within the control group, mean values ± standard deviation, ranged from a baseline mean of 8.5 ± 5.4, to between 5.4 ± 6.9 and 16.4 ± 16.4 for intervals after baseline (Table 2, Figure 2). Comparative data for the NSA recipient group ranged from 3. 5 ± 1.0 (baseline) to between 2.6 ± 3.5 and 3.6 ± 2.2 for the remaining five intervals. Within the control group there were no statistical differences when microvolt data was compared relative to baseline and all subsequent intervals. Moreover, likely due to the large standard deviations, there were no statistical differences (for microvolts or normalized data) between controls and NSA recipients when baseline values and all subsequent intervals were compared, even though the mean microvolt magnitudes were considerable between the two groups (Table 2). Normalized values, evaluated within the control group, revealed significant increases occurring between time intervals two ($p = 0.022$), three ($p = 0.028$), and four ($p = 0.049$) when compared to time interval one, following baseline (Table 2, Figure 2).

Electrodermal Activity (EDA)

Electrodermal activity, recorded in micromhos (umhos), decreased consistently within the NSA recipient group over the second through fifth intervals following baseline. Alternatively, the control group exhibited essentially a constant level of electrodermal activity over the entire time course (Table 3).

Within the group receiving NSA care, significant micromho decreases ($p = 0.001$) were observed between baseline and the third, fourth, and fifth intervals of EDA measurement (Table 3, Figure 3). Moreover, differences also decreased significantly between the first and the second ($p = 0.009$) through the fifth intervals ($p = 0.000$). Additionally, significant decreases in EDA were also revealed between the second interval and the third through fifth intervals ($p = 0.000$). Although mean values expressed a decreasing trend from the third through fifth intervals, there were no significant differences between the remaining times, suggesting a leveling of EDA by the third interval.

Alternatively, within the control group, no significant differences were observed between baseline values and any of the five subsequent intervals, or between any of the five intervals following baseline.

When normalized data within the NSA recipient group was compared, significant decreases were observed between the first interval and the third through fifth intervals ($p = 0.000$). This same phenomenon was also observed between the second interval and the third though fifth intervals ($p = 0.000$), Table 3, Figure 3. Although EDA continued a trend of decreased activity, there were no significant differences between the third or fourth intervals and subsequent time periods. This also indicated a leveling in the decreasing pattern commencing by the third interval.

Within the control group, there were no statistically significant differences in normalized values. However, when normalized values were compared between the control group and the NSA recipient group significant differences were observed for the third ($p= 0.002$), fourth ($p = 0.001$), and fifth ($p = 0.000$) intervals. In each instance, control values represented an increase in EDA from baseline while the same intervals reflected decreases in EDA from baseline in the NSA recipient group (Table 3, Figure 3).

Discussion

The methods used in this study were employed to indirectly evaluate changes in sympathetic nervous system activity in subjects undergoing Network Spinal Analysis (NSA) care. The recording of surface electromyography (sEMG),[13-17, 20-26,29] electrodermal activity (EDA),[8,20,21] and digital (peripheral) skin temp (DST)[8,19,20,29] are well established for such detection. For example, the association between "muscle tension," recorded as increased EMG activity, and sympathetic outflow, is well documented.[13-17]

As previously described, differences in peripheral skin temperature have been taken to be a correlate of changes in peripheral vasoconstriction associated with the sympathetic nervous system.[19,20,29] This relationship is based on the physiological ramifications of vasoconstriction on the temperature of surrounding tissues; that is, tissues surrounding a vascular bed will tend to cool since constricted vessels pass less warm blood than if they were dilated. Thus, tissues tend to warm and cool as the immediate vascular bed constricts and dilates. However, ipsilateral measurements of this parameter (expressed as absolute temperature) has proven difficult, since surface temperatures vary with time, different regions of the body, and between individuals.[19] Thus, the best index of change; contralateral changes in surface temperature, is best suited to detect anomalies in the otherwise symmetrical distribution of temperature. It is apparent from the present study, as well as the scarcity of data derived from other studies, that future measurement of changes in surface absolute temperature will likely require very sensitive instrumentation to detect the subtle changes which occur.

Electrodermal activity (EDA) is an index of choice within the behavioral sciences for indirectly measuring sympathetic activity.[8] This confidence is based on the anatomy of the skin which reveals that eccrine sweat glands abundantly supply the skin in all areas except the lips, concha (outer ear), and the gen-

ital areas. Additionally, the secretory portion of these glands is predominantly innervated by the sympathetic nervous system. Evidence suggests that "bursts" of sympathetic activity elicit electrodermal activity.[11] Study has shown that ventral root fibers innervate the secretory portion of the sweat gland and the muscles controlling piloerection.[8]

Investigators have suggested that EDA involves a number of cortical centers including the premotor cortex, sensorimotor cortex, limbic system, and hypothalamic areas, as well as the reticular formation, which are involved with motivational and emotional behavior.[9,27] These suggestions are of interest since a similar pathway may be involved in generating the respiratory and somatopsychic waves, which are a characteristic response to NSA care.[18]

While sweating serves to cool the body, as well as being a behavioral response, it is necessary to establish some rationale as to which response is most likely to represent an increase in EDA. In this regard, eccrine glands (notably in the fingers) respond only weakly at certain levels of heat, but strongly to psychological and sensory stimuli.[8] Thus, if subjects are studied in a setting with a constant typical room temperature, as in the present study, it is not likely that such an environment would necessitate a "cooling" effect initiated through the hypothalamus. Thus, measurement of the extent of "sweating," in such an environment would more likely be the result of sympathetic nervous system activity associated with some form of psychological and/or sensory stimulation.

Relative to information regarding DST, sEMG, and EDA, interesting findings were recorded in the present study. For example, the varying temperatures conformed to normative data reported elsewhere.[19,20,29] Moreover, there were no significant differences in peripheral temperature within the NSA or control groups, or between groups, over the course of the study. Because both controls and the NSA group exhibited only small changes in peripheral temperature from baseline, normalization of values reflected essentially no change over the five intervals in either of the two groups. Thus, in the absence of instrumentation extremely sensitive to small changes, the present observations suggest normal variation within and between groups rather than any differential in sympathetic activity.

As previously described, the sEMG data collected in the present study was for the purpose of characterizing any overall change in paraspinal muscle activity associated with NSA care, as opposed to a specific diagnostic application. That is, it would be important to record the activity of the paraspinal musculature, right versus left, if muscle activity was being contemplated as a component of the vertebral subluxation.[28] Nevertheless, in the present study, sEMG bilateral data at the level of the sixth thoracic paraspinal musculature is contrasted to that for the same spinal level reported by Gentempo et al.,[28] as well as values reported by Cram and Cahn[13]. The Gentempo study recorded muscle activity of 80 subjects in the seated position reporting values of 8.40 $\pm$ 3.50 microvolts for the left sixth thoracic paraspinal region, and 8.20 $\pm$ 3.50 for the contralateral level, while Cram and Cahn reported values at the sixth thoracic level as 2.5 $\pm$ 2.6 for 104 subjects in the seated position. In the present study, baseline data for the 20 subjects in the NSA group, and the 5 control subjects, conformed to the range reported by the study of Gentempo et al., as well as that of Cram and Cahn. However, neither of the these reports mentioned data collected in the prone position, nor was EMG data collected for a period as long as 17 minutes. Both of the variables may have contributed to the variation among subjects in the present study. In this study, however, it does not appear that altering the position of the patient from the seated to prone position resulted in a change in physiological response. Although physiology may change between the prone versus seated position, the constancy of the DST, the elevation of sEMG activity in controls but not NSA subjects, as well as the opposite changes in EDA in the present study, suggests that the change in position elicited no particular response. However, further study is merited to evaluate the seated and prone positions to ascertain more specifically if any effect can be attributed to one or the other.

The variation in sEMG activity reported in this study, both within and between the control and NSA groups, may also have been due to different states of subluxation within both populations, since muscle activity has been demonstrated to increase in response to stress.[29] Even though mean values varied considerably, between the control and NSA recipient groups, there were no statistical differences. This is consistent with similar findings reported for facial sEMG by Arena and Hobbs.[29] However, there was a significant increase in sEMG activity in the control group when data was normalized against the baseline values. By comparison, such a relative change was not observed in the NSA group, which expressed a slight decrease in mean values throughout the same time period. The continuous increase in paraspinal sEMG in the control group may have been due to the stress of remaining in the prone position for 12.5 minutes after baseline. Alternatively, no such phenomenon was observed in the NSA group, subjected to NSA care after the first 4.5 minutes of the recording procedure. It is, therefore, suggested that the administration of NSA contributed to a more "relaxed" state of those receiving care. While this putative state of relaxation may be speculated to have a conscious component, it is also probable that those under NSA care were experiencing a *"sympathetic quieting effect."*

Further support of a *"sympathetic quieting effect"* associated with NSA was supported by EDA. Electrodermal activity, as previously described, has been linked to sympathetic nervous system output. In the present study, this parameter provided a clear distinction between control subjects and those receiving NSA care. It was evident that the NSA group expressed a steady, significant decline in EDA for the second through fifth intervals following baseline. The control group not only showed no comparable change, but rather displayed a pattern of gradual increase in mean values following baseline.

Within the NSA group, all intervals other than the first were significantly decreased relative to baseline. A pattern was also evident in which each of the intervals was significantly decreased from the first and second intervals following baseline. Since the third through fifth intervals were not statistically different, it is presumed that a "leveling off" effect had occurred between 9.5 - 12.0 minutes under NSA care, which continued through the 17 minute recording period. Although no significant differences within the control group were observed, a different pattern was evident, in which the mean EDA was

observed to increase from baseline in all following intervals. Of interest, the magnitude of the change, relative to baseline, in the control group resulted in EDA activity significantly greater that the NSA group for intervals three through five, the same time periods when the "leveling off" effect was observed in that group. This pattern of increase in EDA in the control group was consistent with the group's increase in sEMG. These observations, taken together, further suggest a lower level of sympathetic activity, or *"sympathetic quieting effect"* in the NSA group, compared to controls.

Another interesting aspect of the current study revolved around the use of music during the 17 minute recording period, for both control and NSA subjects. This was done on the assumption that it created a "relaxing" atmosphere for the patients. However, since the control subjects expressed an increase in sEMG, and EDA following baseline, while the NSA group did not, it is difficult to speculate on the actual influence of the background music. It will, therefore, be important for future studies to evaluate these same physiological parameters in controls and those receiving NSA care in the absence and presence of different types of music.

Conclusions

1. The 20 subjects receiving NSA care experienced a substantial decrease in EDA over the course of a 17 minute recording session. This was accompanied by a stable sEMG pattern and DST, considered peripheral temperature. By contrast, the 5 subjects receiving no intervention experienced a constant DST, but expressed substantial increases in sEMG activity when relative (normalized) to the baseline value. As well, the control group expressed a pattern of increased EDA activity relative (normalized) to baseline, which was also significantly higher than the NSA group for the same intervals. These findings suggest a higher level of sympathetic activity in the control group, perhaps associated with the 17 minute period required for the recording protocol. By contrast, the NSA group, subjected to the same protocol exhibited an apparent *"sympathetic quieting effect"* which, in this preliminary study, appears to be associated with the NSA care.

2. There is no ready explanation for the lack of digital temperature change in the two groups other than to speculate that the extent of sympathetic change was not great enough to elicit a change in skin temperature. It may also be that the instrumentation was not sensitive enough to detect small changes in temperature, thus resulting in fairly large standard deviations, which when applied to closely matched temperature values resulted in a statistical type II error. Further study with more sensitive instrumentation will be required to test this hypothesis.

3. Additional study will also be required to confirm the findings presented herein. The present study was limited by available subjects meeting the inclusion criteria. Thus, even though the present study was preliminary in nature, it is evident that a larger population of subjects, notably more controls, will have to be assessed under the same setting to gather more information on the measures studied as well as other parameters indirectly measuring sympathetic response. This will be necessary to enhance the statistical power of further evaluations, and also to provide a broader base of subjects upon which to more thoroughly assess gender and age effects. Another important element to be considered involves the application of NSA care. The protocol, while the same in concept, is administered differently as patients progress through the three levels of care.[1] It will, therefore, be important to assess subjects who are representative of each of these three levels. The present study did not clearly differentiate that aspect of care, and consequently, may have masked changes which otherwise would be more characteristic of Level One, Level Two, or Level Three.[1]

4. While the present data must be interpreted with caution for the reasons stated, it is apparent that a *"sympathetic quieting effect"* may be operable during NSA care. This is consistent with its hypothesized mode of action linking cortical centers, the limbic system, hypothalamic areas, and the reticular formation to the generation of the somatopsychic and respiratory waves, characteristic of NSA care. Moreover, it is also consistent with significant self reported improvements in wellness domains including mental/emotional state and stress evaluation.[2]

References

1. Epstein D. Network Spinal Analysis: A system of health care delivery within the subluxation-based chiropractic model. Journal of Vertebral Subluxation Research 1996; 1(1): 51- 59.
2. Blanks RH, Schuster TL, Dobson M. A retrospective assessment of network care using a survey of self-rated health, wellness, and quality of life. Journal of Vertebral Subluxation Research 1997; 1(4): 15 - 31.
3. Sandin B and Charnot P. Changes in skin, salivary, and urinary pH as indicators of anxiety level in humans. Psychophysiology 1985; 22: 226-230.
4. Morse D, et al. Stress, relaxation and saliva: A follow-up study, involving clinical endodontic patients. Journal of Human Stress 1981; 7: 19-36.
5. Morter MA, Schuster TL. Changes in salivary pH and general health status following the clinical application of Bio-Energetic Synchronization. Journal of vertebral subluxation Research 1998; 2(1): 35 - 41.
6. Woodworth RS, and Schlosber H. Experimental Psychology. New York: Holt, 1954.
7. Andreassi J. Psychophysiology: Human behavior & physiological response; third ed., Hillsdale, NJ.,Baruch College, City University of New York Lawrence Erlbaum (publishers).
8. Edelberg R. Electrical activity in the skin. In NS Greenfield & RA Sternbach (Eds.), Handbook of psychology. New York: Holt, Rinehart & Wilson, 1972: 367-418.
9. Edelberg R. Electrodermal recovery rate, goal-orientation and aversion. Psychophysiology 1972; 9: 512-520.
10. Woodburne RT. Essentials of human anatomy. New York: Oxford University Press, 1978.
11. Wilcott RC. Arousal sweating and electrodermal phenomena. Psychological Bulletin 1967; 67: 58-72.
12. Schwartz MS. Biofeedback: A practitioner's guide. New York; The Guilford Press. DATE : 76.
13. Cram JR, Cahn TS. EMG muscle scanning: A diagnostic protocol for back pain. Pain Management 1988 (January/February): 28-36.
14. Budzynski T, Stoyva J, Adler C, and Mullaney DJ. EMG biofeedback and tension headache: A controlled outcome study. Psychosomatic Medicine 1973; 35: 484-496.
15. Fried JJ. Biofeedback: Teaching your body to heal itself. Family Health 1974; 6: 18-21.
16. Reeves JL, and Mealiea WL. Biofeedback-assisted cue-controlled relaxation for the treatment of flight phobias. Journal of Behavior Therapy & Experimental Psychiatry 1975; 6: 105-109.
17. Braud LW, Lupin MN, & Braud WG. The use of electromyographic biofeedback in the control of hyperactivity. Journal of Learning Disabilities 1975; 8: 420-425.
18. Epstein DM. Theoretical basis and clinical application of network spinal analysis (NSA). Boulder CO. Association for Network Chiropractic 1998.

19. Uematsu, S, Edwin DH, Jankel WR, et al. Quantification of thermal asymmetry. Part I: Normal values and reproducibility. J. Neurosurg. 1988; 69: 552-555.
20. Arena JG, Hobbs SH. Reliability of psychophysiological responding as a function of trait anxiety. Biofeedback and Self-Regulation 1995; 20 (1): 19-37.
21. Kimura J. Electodiagnosis in diseases of nerve and muscle. Philadelphia, PA: FA Davis, 1985.
22. Andersson G, Jonsson B. Ortengren R. Myoelectric activity in individual lumbar erector spinae muscles in sitting. A study with surface and wire electrodes. Sc and J Rehab Med 1974 Suppl; 3-91.
23. Dolan P. Mannion AF, Adams MA. Fatigue of the erector spinae muscles. A quantitative assessment using frequency banding of the surface electromyographic signal. Spine 1995; 20(2): 149.
24. Kent C, Gentempo P. Protocols and normative data for paraspinal EMG scanning in chiropractic practice. Chiropractic 1990; 6(3): 64.
25. Ellestad S, Nagle R, Boesler D, KilmoreM. Electromyographic and skin resistance responses to osteopathic manipulative treatment for low-back pain. JAOA 1988; 88(8): 991.
26. Haig AJ, Gelblum JB, et al. Technology assessment: the use of sEMG in the diagnosis and treatment of nerve and muscle disorders. Muscle & Nerve 1996; 19: 392.
27. Venables PH, and Christie MJ. Mechanism, instrumentation, recording techniques, and quantification of responses. In WF Prokasy and DC Raskin (Eds.), Electrodermal activity in psychological research. New York: Academic Press, 1973: 1-124.
28. Gentempo P, Kent C, et al. Normative Data for paraspinal surface electromyographic scanning using a 25 - 500 Hz bandpass. Journal of Vertebral Subluxation Research 1996; 1(1): 43 - 46.
29. Arena JG, and Hobbs SH. Reliability of psychophysiological responding as a function of trait anxiety. Biofeedback and Self-Regulation 1995; 20(1): 19-37.