CLINICAL PRACTICE

The Clinical Application of Surface Electromyography as an Objective Measure of Change in the Chiropractic Assessment of Patient Progress: A Pilot Study

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Abstract — A pilot study was conducted to evaluate the application of sEMG, as recorded with the Insight 7000 TM Subluxation Station, to the chiropractic clinical setting as an objective measure of change in assessing patient progress. The study revealed that intra-examiner reliability could be demonstrated through a paired two-tailed t-test which takes variation into consideration, rather than using correlation coefficients which could mask examiner error. Thirty patients under the care of 19 different supervised interns in a clinical teaching setting, were, over a four week period, administered a wide range of adjustments in accordance with a planned regimen of care. Findings revealed that all patients experienced a gradual to significant decline in sEMG activity in either the right and/or left side, in 14 of the 15 paraspinal muscular segments evaluated. This suggested a long term effect in sEMG activity changes, as opposed to a short term physiological response. Additional study is underway to evaluate inter-examiner reliability of the Insight 7000 Subluxation Station in the clinical teaching setting. Investigation is also planned to couple sEMG changes to other physical finding. This level of study is expected to contribute to an understanding of the clinical significance of the effects of the chiropractic adjustment on paraspinal muscular activity.

Key Words: Surface electromyography, EMG, sEMG, Insight 7000 Subluxation Station, muscle activity, vertebral subluxation, chiropractic clinical practice.

Introduction

Chiropractic was established in 1895 by D.D. Palmer.[1] Due, perhaps to the relatively short period since its inception, chiropractic practice has relied to a large extent on subjective indicators for patient assessment.[2] There have been, and continues to be, both published as well as anecdotal reports by both practitioners and patients, of physical and quality of life changes in association with chiropractic care. However, the availability of reliable instruments to objectively measure physical and quality of life changes in patient progress, has only recently emerged[3,4]

Evaluation of the tone of paraspinal musculature is an integral part of the chiropractic assessment.[5] The information derived from palpation contributes to the clinician's evaluation of the presence of spinal dysfunction, and hence the necessity to initiate, continue, and/or change the plan of patient care.

Fundamental to the traditional concept of chiropractic practice is the correction of the condition of vertebral subluxation (VS).[1] The traditional model of chiropractic, as well as recent models which have build on its tenets,[5-7] impress the clinical significance of evaluating the soft tissue component of this condition. Chiropractors commonly assess paraspinal musculature tone through manual palpation.[5,9] Unfortunately, manual palpation is subjective, apparently associated with a range of variables which impact on the skill levels of clinicians. This may account

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for the wide range of correlation observed in different inter and intra-examiner muscle palpation reliability studies.[10-14] Thus, other than signs and symptoms, the practitioner is limited in means of objective assessments which provide evidence of changes in patient progress.

In this regard, the literature supports the evolution of surface electromyography (sEMG) as a reliable and valid measure of change in muscular activity.[3] Surface EMG measures muscle electrical activity generated through the action potential.[3] There are two approaches to obtaining EMG data. Needle EMG, which involves insertion of needles beneath the skin into the muscle being examined, and sEMG which measures activity via electrodes placed on the skin. This study has focused on sEMG. The advantages for this approach have been described in the literature, and summarized by England and Diebert;[15] (a) Potentials are clearly visible over interference using surface electrodes, whereas needles only reduce baseline interference, (b) Patient acceptance is better with surface electrodes as it is non-invasive and not as time consuming, (c) Evoked potential studies routinely are done using surface electrodes, and the results are legally admissible evidence in litigation, (d) Needles inserted into a muscle could produce uncontrolled and largely unexplored reactions, (e) Depth of the needle electrodes may not represent all segments innovating a muscle and would, therefore, not be adequately informative to the chiropractor to identify all segments involved in muscular impairment from neurological impairment, (f) In many jurisdictions it is illegal for chiropractors to penetrate the skin, and (g) the motor unit capture area of a stable surface electrode is constant, whereas a needle has to sample motor units (possibly irritating tissues).

The literature describing and evaluating sEMG is extensive, and has been reviewed by others.[16,17] Test-retest studies[18] with sEMG have demonstrated very good to excellent reliability with correlation coefficients of 0.73 to 0.97. Komi and Buskirk[19] reported a test-retest reliability coefficient of 0.88 for sEMG, compared to 0.62 for needle EMG.

Ellstead et al.,[20] found sEMG paraspinal muscular activity to decrease following osteopathic manipulation. Although the methodology of manipulation is different from that of the chiropractic adjustment,[21] the application of objectively measuring paraspinal activity applies to both. A similar result has been reported by Shambaugh[22] who showed sEMG decreases of 25% in the erector spinae group, following administrations of force to several vertebral segments including T1, T3, T5, L1, and L3. Shambaugh's study included application of force to the same segments in each subject, and was not based on clinical assessment. Since there is sEMG evidence that muscle activity can decrease following an administration of force to the spine, it becomes important to differentiate between a short term decrease in muscular activity, especially in areas of hyperactivity, from a long term clinical effect. One objective of the present pilot study has been to observe progress over a four week period to assess change in muscular activity in relationship to ongoing chiropractic care. This approach is important in providing information regarding the usefulness of sEMG data in patient assessment in a setting which reflects a clinical environment with patients undergoing chiropractic care administered to each individual's specific needs.

Materials and Methods

Instrumentation

The present study was conducted using the Insight 7000 TM sEMG Subluxation Station (Paterson, New Jersey). The unit consists of two Smart Sensors™ which are lightweight hand held electrode assemblies, with a miniaturized preamplifier. The unit scans at a band pass of 25-500 Hz with a 15 point level of smoothing.[23] Muscle activity, recorded in micro-volts, is compared by internal software of the Insight 7000 against a standard base of normative data.[24] Once the unit analyzes the data, findings are displayed on screen as a bar graph demonstrating sEMG activity. The measurements are displayed for different vertebral segmental levels as a function of the number of standard deviations from the normative database values (Figure 1). In this study 15 vertebral segmental levels were evaluated.

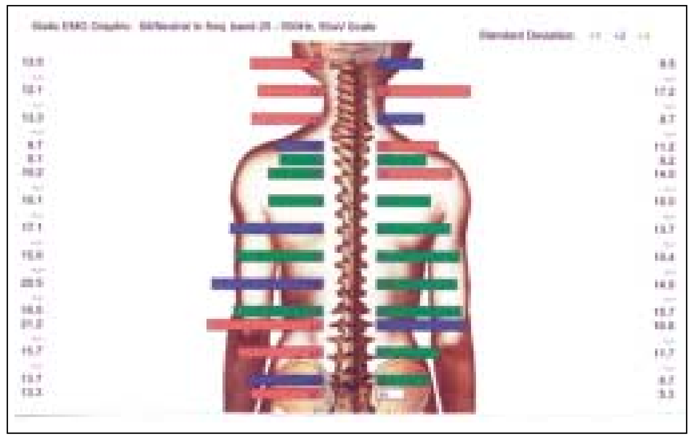

Figure 1.

Prior to commencing the clinical aspect of the study, a trial of intra-examiner reliability was conducted to enhance the validity of changes which might occur when recorded on patients. On two separate occasions, three days apart, a 23 year old male with no known spinal dysfunctions or other physiological disorders, was scanned with the Insight 7000. On each day, two groups of ten full spine sEMG scans were taken with a five minute resting period between the tenth and eleventh scans. Since muscular activity could change from day to day, each set of ten readings was compared against the other set of ten readings only on the day they were taken.

The Insight 7000 was interfaced with a Authentic AMD Pentium computer, with 31 MB RAM and a 233mHz processor, run on the Microsoft® Windows 95 system.

Study Design

Patient Selection

A subject pool of 30 patients was utilized. The subjects asked to participate were drawn from new patients presenting for care at the clinic training facility of the New Zealand Chiropractors' Association (NZCA) School of chiropractic, located in Auckland. Patients who presented with disc involvement or history of spinal injury were excluded, as aberrant sEMG patterns have been shown to be associated with these conditions.[25-28]

The study was limited to 30 subjects to coincide with the time frame which was available to senior interns to participate in research as part of the chiropractic training program. All aspects of patient evaluation, plan of care, and administration of adjustments was approved and supervised by registered practicing chiropractors who served as tutors in the School's clinic facility.

The study was approved by the NZCA School's Ethics Procedure which involved ethics approval through the Auckland Institute of Technology. After a full disclosure of the nature and conditions of the investigation, written informed consent to participate was obtained from each subject prior to the study, including the individual that served as a subject for the intra-examiner reliability trial. The 30 subjects were under the regular care of a total of 19 supervised interns. All interns were "blinded" to sEMG findings of the patients participating in the study.

Data Collection and Analysis

Data was collected during the months of August through mid-October, 1998. Fifteen males and fifteen females were evaluated. Females ranged in age from 22 years of age to 57 (mean = 33.4 ± 12.0). Males ranged in age from 24 years of age to 80 (mean = 39.6 ± 4.9). Each subject was treated in the customary fashion at the clinic training facility. This involved a patient history, physical examination accompanied by a chiropractic examination for indications of vertebral subluxation. Included were static and motion palpation,[9,29] joint play and end feel,[9] Derefield-Thompson leg length assessment,[30] and muscle challenge testing.[31] When evidence of spinal dysfunction was determined, full spine x-rays were taken to obtain information of contraindication to adjustment, as well as being used for analysis of the area to be adjusted.[32]

Based on the chiropractic assessment, when appropriate, the 19 participating student interns used one or more of the following chiropractic adjustment techniques: Palmer Upper Cervical,[5] Diversified,[5] Gonstead,[33] and Thompson Terminal Point Technique.[30]

During the report of findings visit, scheduled after the initial examination and evaluation and prior to the first adjustment, each patient was sEMG scanned to obtain baseline values at fifteen contralateral (paired) paraspinal vertebral segment levels; C1, C3, C5, C7, T1, T2, T4, T6, T8, T10, T12, L1, L3, L5, and S1. All patients, including the intra-examiner reliability trial subject, were scanned under the same conditions and methods.

Each gowned patient was first rested prone for five minutes to relax and acclimatize to the ambient temperature which ranged from 20-22 degrees centigrade. The patient was then seated and their back exposed for the scan. The seated position served to create axial loading on the spine, consistent with other aspects of the assessment procedure such as radiography. The subjects' hands were placed palm up on the lap to relax the shoulder muscles, and legs were uncrossed. Each patient was instructed to focus on a point on the wall in front. The skin was wiped with isopropyl alcohol prior to placing the sEMG electrodes.

After activating the scan, when the micro-volt signals stabilized,[23] the sEMG reading was recorded by depressing a foot pedal. All readings were taken in a caudal direction, with the sensors placed approximately 2 cm lateral on each side of the spinous process at each segment level.

When baseline data was obtained, this procedure was repeated one week after the first adjustment, and then three weeks later (four weeks from the first adjustment). The second scan was also conducted prior to the adjustment, while the third was obtained after the third adjustment. This design was chosen to evaluate if changes, other than being a reflection of an immediate response to the adjustment, could be characterized as long term change.

Statistical Analysis

Subjects were assigned a score which was equivalent to the number of standard deviations from the normative data base, as analyzed by the Insight 7000 software.

A two-tailed t-test ($p<0.05$) was used to evaluate the results of the intra-examiner reliability trial.

Patient data was evaluated through the statistical package of SAS® for Windows, version 6.12. Data was analyzed by analysis of variance (ANOVA) and Tuckey's HSD post hoc test,[34] to compare pairs of means for significance ($p<0.05$).

Results

Intra-Examiner Reliability

The test-retest trial, conducted on two separate occasions three days apart, was evaluated by comparing the mean values for each segment, read ten times in each set. For the purposes of this study, the examiner was considered reliable when the two sample means did not fall below an alpha of 0.05 ($p<0.05$), which would have indicated that the two sample means were statistically different. Among the two sets of data evaluated on day one, alpha's were less than 0.05 for C5 right, and T1right. Alpha's for the remaining segments ranged from 0.13 to 1.00, with a median of 0.31, and mode of 0.25. On the second test-retest trial, alpha's ranged from 0.06 to 0.98. with a median of 0.60 and a mode of 0.86. No alpha values were recorded less than 0.05.

Adjustments

Among the 30 subjects, a range of adjustments were administered relative to the different segmental levels of the spine. Within the subject pool, over a period of four weeks, a total of 398 adjustments were administered by 19 interns to their respective patients/subjects. In terms of frequency, the cervical spine was adjusted 39.2% of the time, the thoracic spine 22.4% of the time, the lumbar spine 5.8%, the sacrum (left and right collectively) 11.6%, and the ilium 21.1% (Table 1). Relative to frequency of adjustments, the rank order of segments adjusted by frequency is also provided in Table 1. The most frequently adjusted segment was ilium (21.1%), and the least frequent was L1 (0.25%).

Change in sEMG Activity

Means for all paraspinal segmental levels of the 30 subjects

Table 1. Percent Distribution of Segmental Regions Adjusted in the Subject Population, and Rank order of Frequency of Adjustments per Segment.

	Segmental Region				
	Cervical	Thoracic	Lumbar	Sacrum	Ilium
Percent	**39.2**	**22.4**	**5.8**	**11.6**	**21.1**
Rank order by percent					
1.					21.1
2.	13.0 (C1)				
3.				11.6	
4.	9.8 (C7)				
5.		6.3 (T1)			
6.	5.3 (C2)				
7.		4.5 (T4)			
8.	4.0 (C3)				
9.	3.2 (C5)				
12.	2.0 (C6)	2.0 (T7)	2.0 (L3)		
10.		2.8 (T8)			
11.		2.3 (T6)			
13.	1.8 (C4)		1.8 (L4)		
14.		1.3 (T2)			
15.		1.0 (T3)			
		1.0 (T9)	1.0 (L2)		
16.		0.75 (T5)	0.75 (L5)		
17.		0.50 (T10)			
18.			0.25 (L1)		

exhibited a continuous pattern of gradual to statistically significant decline in sEMG muscle activity over a four week period, which included the adjustment visits (Table 2).

Statistical evaluation employing ANOVA and Tukey's HSD post hoc test, revealed four categories of change in sEMG activity of paraspinal musculature in the 30 subject sample; (a) segments which significantly declined in activity, after one week compared to baseline ($p<0.05$), remaining significantly different from baseline at week four; (b) segments which significantly declined in activity after 4 weeks ($p<0.05$), but were not significantly different at one week, compared to baseline; (c) one segment which declined significantly at four weeks compared to baseline and week one; and (d) segments which showed no significant decrease in activity after four weeks, compared to baseline or week one. To visualize these patterns of change, the mean standard deviation differences from the normative sEMG data pool, as analyzed by the Insight 7000 Subluxation Station, have been plotted by selecting a representative segmental area of each pattern (Figure 2).

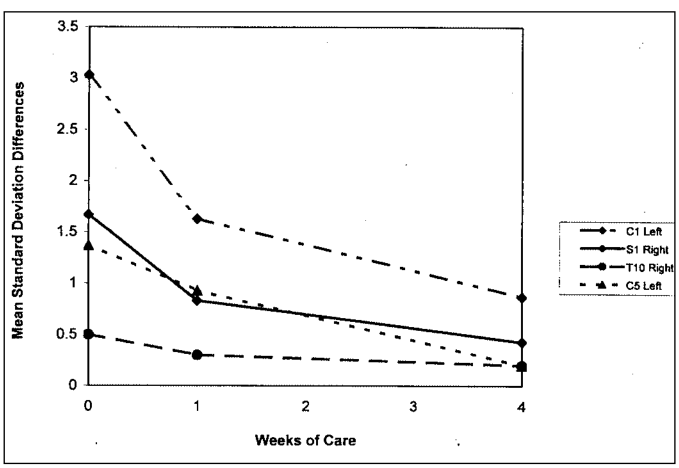

Figure 2. The graph depicts a representative of the four categories of response among the various segments assessed through sEMG. The paraspinal muscular region of the C1 left segment exhibited a significant decline in activity from baseline at weeks one, and four. The S1 right segmental area was significantly lower than baseline at week four, but not at week one. The C5 segmental area was significantly lower at week four from week one and baseline. The T10 segmental area exhibited no significant difference from baseline either at week one or week four.

Results of the study revealed that fourteen of the fifteen segments (either right and/or left), exhibited significant declines in sEMG activity. Significant declines in sEMG activity were observed at week one relative to baseline in 12 out of 15 segmental levels, although variations occurred between right and left sides of the spine (Table 2). Surface EMG readings of Fourteen of the fifteen spinal segmental levels revealed significant declines in muscular activity after four weeks, compared to baseline (Table 2.). Only segmental levels T6 (right), T10 left and right, and L1 right showed no significant difference from baseline or week one (Table 2). These levels represented 13.3% of the total segmental levels which did exhibit significant declines in s EMG activity over the four week period.

Discussion

The aim of the present pilot study was to evaluate the application of sEMG as an objective measure of change in the clinical assessment of patients under chiropractic care. This study was

Table 2. Surface EMG Activity+ in Paraspinal Musculature over a Period of Four Weeks of Chiropractic Care.

Segment	Baseline	Week One	Week Four
C1 Left	3.03	1.63*	0.87*
C1 right	2.00	1.27	0.40*
C3 left	2.43	1.20*	0.57*
C3 right	2.77	1.10*	0.37*
C5 left	1.37	0.93	0.20*°
C5 right	1.37	0.70	0.20*
C7 left	1.60	0.63*	0.27*
C7 right	1.30	0.47*	0.17*
T1 left	1.27	0.60	0.13*
T1 right	1.13	0.33*	0.00*
T2 left	1.43	0.70*	0.20*
T2 right	1.30	0.33*	0.03*
T4 left	0.90	0.47	0.13*
T4 right	1.10	0.33*	0.03*
T6 left	1.20	0.53	0.23*
T6 right	0.60	0.27	0.13
T8 left	0.80	0.27	0.13*
T8 right	0.53	0.23*	0.13*
T10 left	0.47	0.30	0.27
T10 right	0.50	0.30	0.20
T12 left	0.50	0.23*	0.20*
T12 right	0.60	0.23	0.13*
L1 left	0.73	0.33*	0.27*
L1 right	0.43	0.27	0.23
L3 left	1.73	0.80*	0.60*
L3 right	1.13	0.60	0.33*
L5 left	1.53	0.57*	0.57*
L5 right	1.20	0.37*	0.27*
S1 left	2.07	0.93*	0.53*
S1 right	1.97	0.83	0.43*

+ Numbers represent the mean standard deviation differences of 30 Subjects compared to Normative Data (see Methods).
* Denotes a significant difference ($p<0.05$) from baseline (See Methods).
° Denotes a significant difference ($p<0.05$) between week one and week four.

conducted in a clinical teaching environment oriented to the correction of vertebral subluxation as an inherent part of each patient's plan of care.

While considerable study has provided evidence as to the reliability of sEMG, little information has been available concerning the application of the methodology to the clinical setting. Studies in the "laboratory setting" are designed to evaluate sEMG change in activity following force application to the spine, incorporating a study paradigm requiring all subjects to be "adjusted" at the same segmental levels. However, information derived from a study design of that type does not offer information as to what might be expected in a subject group receiving adjustments at different segmental levels, consistent with the patients' plan of care.

Another aspect of assessing the clinical application of sEMG involves the necessity to evidence the intra-examiner reliability of the clinician. In that regard, while the use of appropriate correlation coefficients in studies measuring the reliability of several examiners may provide a measure of their comparative consistency, intra-examiner reliability coefficients are less meaningful, as they could reveal a high level of self-consistency, but may mask examiner error.[35]

Relative to the present study, considering the limitation of intra-examiner reliability as reflected through correlation coefficients, it was considered most appropriate to use a two-tailed paired t-test to compare means of the intra-examiner trial population samples. This approach revealed that of the 15 paraspinal regions, assessed in four sets of ten each (a total of 600 readings), only two fell below an alpha of 0.05, suggesting that those reading were too variable to be considered as the same population. Thus, in 99.7% of the paired trials, variation, which is expected by both the examiner, as well as the physiological system, was not sufficient to distinguish the samples as significantly different. In this study, it was considered necessary to demonstrate a statistically acceptable level of examiner consistency to enhance the validity of true change in the patient, as opposed to examiner error in the use of the sEMG method.

As depicted in Table 1, Figure 2, all patients, regardless of the type and/or frequency of adjustments given, exhibited a gradual to statistically significant decline in paraspinal muscular activity over the four week period. The present study was not designed to investigate the effect of specific adjustments on any specific region of the paraspinal musculature to changes in sEMG activity, but rather to evaluate changes in muscular activity under a wide range of different types and locations of chiropractic adjustments. This approach was considered to be typical of clinical practice as opposed to the "laboratory setting." The extent of this range is demonstrated in Table 2.

The 30 patients under the care of 19 different supervised interns rendering adjustments to 24 different spinal segments, showed consistent patterns of decline in activity over a four week period. This suggests that the effects were long term and not merely an immediate response of the body to the application of force. This is further substantiated by the observation that the decline was observed in both instances when the readings were obtained prior to the adjustment (baseline and week one), as well as after the adjustment (week four).

An important aspect of this study is that the location of the "adjustment" was not the constant upon which changes in sEMG activity was measured, as many different segments were adjusted. Rather, the constant was the assessment protocol of the patient leading to the adjustment. All interns in the Clinic facility are monitored to assure that the same protocols are adhered to, with regard to patient assessment, and that adjustments are delivered as a consequence of need. Thus, it is concluded that within the scope and conditions of this pilot study, that change in sEMG activity can be considered an objective assessment of patients under the type of chiropractic care administered.

Future study will be conducted with the Insight 7000 subluxation station, at the NZCA School of Chiropractic clinic facility, with regard to inter-examiner reliability. This will be necessary to establish the level of consistency among the number of interns that will incorporate sEMG findings as part of patient assessment. Moreover, it will be interest for further study to evaluate patient progress by coupling specific areas of sEMG changes in activity to other physical changes. This information will be useful to evaluate the clinical significance and relationship of declining sEMG activity relative to the type of chiropractic care involved in terms of location of adjustments.

Summary and Conclusions

Surface EMG has been evaluated in a pilot study as to its application as an objective measure of change in the assessment of patients under chiropractic care. It was observed that over a wide range of segments adjusted, by different supervised chiropractic interns, the population of subjects exhibited a gradual to significant decline in sEMG activity in fourteen of the fifteen spinal segmental regions evaluated.

In consideration of the necessity in clinical practice to demonstrate intra-examiner reliability, it is considered appropriate to evaluate consistency by paired two tailed t-test, which take variation into consideration, rather than rely upon correlation coefficients which may mask examiner error.

Under the conditions of this study, using the Insight 7000 Subluxation Station, it is concluded that sEMG is an objective measure of change which can be used as an assessment of patient progress. Moreover, it appears that the sEMG activity changes occured in association with chiropractic care as a long term effect, rather than a short term physiological reaction to force application.

Additional study is required to establish inter-examiner reliability for use of the Insight-7000 in the clinical training setting, and to relate changes in sEMG to other physical findings to establish the clinical significance of the effects of chiropractic care on this parameter.

Acknowledgments

The authors wish to acknowledge the chiropractic interns and the senior faculty at the NZCA School of Chiropractic for their cooperation, assistance and guidance provided in the completion of this study and the preparation of the manuscript. The authors also wish to thank Dr. Philip Voss of Massey University, Albany New Zealand for his assistance in statistical analysis. The authors also wish to thank Drs. Christopher Kent and Patrick Gentempo for their gift of the Insight 7000 Subluxation Station to the NZCA School of Chiropractic. Also acknowledged is Dr. Gerald Christian for his timely support in supplying necessary software for the analysis of data.

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