DYNAMIC PARASPINAL SURFACE EMG: A Chiropractic Protocol

Christopher Kent, D.C. and Patrick Gentempo, Jr., D.C.

ABSTRACT

Surface electrode paraspinal EMG scanning is growing in popularity as a method for quantifying the muscular changes associated with vertebral subluxations. SEMG techniques are also used as outcome assessments for chiropractic care. This paper discusses the dynamic assessment of paraspinal muscles using affixed surface electrodes. A protocol for dynamic SEMG assessment in chiropractic practice is described. Sample graphs of SEMG acquisitions utilizing this protocol are included in this paper.
INTRODUCTION

Surface electrode paraspinal EMG scanning is a popular technique for quantifying paraspinal muscle dysfunction. Two types of paraspinal EMG scanning techniques are currently utilized in chiropractic practice, neutral static studies and end-point range of motion studies. Although termed "range of motion" studies by their developers, these examinations involve the collection of EMG potentials while the patient assumes static postures at the end points of various ranges of motion.

Neutral static studies are performed with the patient in a neutral standing or seated position. Hand-held electrode sets are applied to designated sites along the paraspinal region, and the signals are processed by a computer. Cram compiled normative data for asymptomatic and pain patients in the standing and seated posture. Kent and Gentempo developed a static scanning protocol for chiropractic analysis, and compiled normative data on asymptomatic subjects. Thus, the EMG signals from the patient under examination can be compared to those of a normative population.

Brody devised a surface electrode technique termed an "orthopedic range of motion" study. This terminology is somewhat misleading, since the EMG acquisitions are performed while the patient maintains a static position at the end point of motion in a given plane. Hand-held electrodes are applied to specific paraspinal sites while the patient maintains the end point position. Unfortunately, this procedure has several significant shortcomings:

1. By monitoring only end-points of the various ranges of motion, abnormal EMG activity occurring between the end points is likely to be missed.
2. Maintaining contorted postures for prolonged periods of time is uncomfortable and adversely affects the stability of EMG signals. Nausea and severe fatigue have been reported in patients undergoing such examinations.
3. Recordings are not made on both sides simultaneously.

Modifications of the end-point examination have been described by Berman and Marcarian and Leach et al. In one small study (16 volunteers) Leach et.al. found that asymmetrical EMG activity and absence of flexion relaxation could be useful in discriminating patients with a "robust" level of back pain from non-pain controls. The study did not address changes in surface EMG activity in lateral flexion and rotation, and was limited to the lower thoracic and lumbar spine.

Other investigators have reported patterns of EMG activity which occur during motion. These investigators employed adhesive surface electrodes to monitor EMG activity throughout the range of motion being studied. Thus, data collection was not limited to static readings taken at end points of motion. A summary of these findings follow, along with a suggested protocol for chiropractic real-time dynamic assessment.

DISCUSSION

THE FLEXION RELAXATION PHENOMENON

Allen observed that when the trunk is flexed, the lumbar paraspinal muscles exhibit EMG activity as eccentric contraction controls trunk lowering. However, when the end range of lumbar flexion is reached, the lumbar paraspinal muscles exhibit electrical silence. This is
believed to be a result of lumbar spine support by posterior ligamentous structures rather than active muscles.

Floyd, Silver\textsuperscript{7,8} and Pauley\textsuperscript{9} suggested that the erector spinae muscles are more active in extension than in flexion. These investigators noted the phenomenon of electrical silence in the erector spinae muscles during full trunk flexion. Wolf et al\textsuperscript{10} observed EMG silence might occur when trunk flexion exceeded 70 degrees and reported that such relaxation occurred most commonly between 80-90 degrees. EMG activity usually resumed after 20 degrees of extension from the fully flexed trunk position, but occurred anywhere from 90-30 degrees of flexion. Floyd and Silver reported that in patients experiencing "back-ache," the flexion relation phenomenon was absent. In addition, Triano and Schultz\textsuperscript{11} found that presence or absence of the flexion relaxation phenomenon was related to scores on the Oswestry low back pain questionnaire. They concluded, "These findings imply that myoelectric signal levels, trunk strength ratios, and ranges of trunk motion may be used as objective indicators of low-back pain disability."

Ahern et al.\textsuperscript{12} investigated the reliability of lumbar paravertebral surface EMG in a sample of 70 patients with chronic low back pain. Patients were evaluated in the standing and seated positions. SEMG was also performed during flexion/extension, rotation, walking, and stooping. These authors calculated a flexion-extension index by subtracting the minimum from the maximum EMG values occurring at maximum flexion. Rotation indices, representing the difference between right and left EMG at maximal rotation were also determined. Within session reliability was calculated using Pearson's "r." Coefficients ranged from 0.66 to 0.97. In another study, Ahern, et.al.\textsuperscript{13} compared the lumbar paravertebral SEMG patterns in chronic low back pain patients with those of non-patient controls. They found significant differences between groups on low back muscle activity during dynamic movements. Such differences were not observed using static postures.

Meyer, et.al.\textsuperscript{14} examined ten subjects to see if the flexion relaxation phenomenon was also present in the cervical spine. Surface electrodes were placed parallel to the cervical paraspinal muscles, and EMG activity was recorded as the patient was instructed to flex the cervical region. The investigators noted that in the cervical spine, end range of motion occurs after full forward flexion. It was concluded that cervical paraspinal muscles exhibit a flexion relaxation pattern similar to that which occurs in the normal lumbar spine. Full-flexion relaxation was observed in all ten asymptomatic subjects.

LATERAL FLEXION AND ROTATION

Dolce and Raczynski\textsuperscript{15} reported that during lateral flexion (side bending) the erector spinae muscles demonstrate increased activity on the contralateral side. Wolfe et al\textsuperscript{10} found that during rotation, increased paraspinal muscle activity occurs on both sides. The side contralateral to the direction of rotation displays significantly more activity than the ipsilateral side. These studies, however, were limited to the lumbar paraspinal muscles. At the end points in lateral flexion, Brody\textsuperscript{3} and Berman and Marcarian\textsuperscript{4} observed elevated EMG potentials on the side opposite the lateral flexion. These authors also observed elevated EMG potentials on the ipsilateral side of the cervical and upper thoracic spine in rotation, and on the contralateral side in the lower thoracic and lumbar region.

Donaldson and Donaldson\textsuperscript{16} and Cram\textsuperscript{17} employed dynamic SEMG examinations as
outcome assessments for biofeedback therapy. These examinations included flexion, extension, lateral bending, and rotation, and were not confined to the lumbar region. Donaldson and Donaldson\textsuperscript{16} examined 276 persons in pain (200 clinical patients and 76 research subjects) and reported that in 97.5\% of these cases, a 20\% or greater imbalance was measured. Examination of a control group of 40 non-pain subjects found asymmetries ranging from 5\% to 10\%.

Furthermore, Donaldson and Donaldson\textsuperscript{16} described two "rules" which they used to discriminate between pain and non-pain patients:

1. In non-pain subjects symmetrical movement produces symmetrical patterns.
2. In pain patients symmetrical movement produces asymmetrical patterns.

Thus, it appears that dynamic SEMG studies may have clinical utility in discriminating between pain and non-pain populations. To the chiropractor, however, there are several significant shortcomings to pain-based models for outcome assessment:

1. Such schemes assume that the objective of chiropractic care is symptomatic treatment of pain.
2. Pain is a highly subjective, private sensation which cannot be directly measured or observed.
3. In some instances, unless the pain is robust enough to restrict activities of daily living, a "false negative" could result.
4. Pain criteria cannot be applied if the patient has symptoms other than pain, or no symptoms at all.
5. Pain criteria are useless in the evaluation of asymptomatic patients undergoing maintenance or reconstructive care.

If the objective of chiropractic care is the correction of vertebral subluxations, criteria must be developed which reliably evaluate their presence and correction. The authors suggest that the following be used when considering outcome assessments:

1. The procedure should reliably measure a generally accepted manifestation of the vertebral subluxation complex.
2. The information obtained should be useful in the planning of clinical strategies, such as the need for adjustment, frequency of visits, and determination of indications for maintenance care.

Alterations in spinal mobility and asymmetrical muscular activity are generally recognized manifestations of vertebral subluxation.\textsuperscript{18-19} Therefore, dynamic SEMG studies may be useful in analyzing subluxations as well as discriminating between pain and non-pain populations.

**PROTOCOL FOR DYNAMIC ASSESSMENT OF PARASPINAL MUSCLES**

The authors have developed a protocol for the dynamic assessment of paraspinal muscle activity in chiropractic practice. A two channel computerized EMG scanner is used in conjunction with pre-gelled disposable, self-adhesive electrodes. The skin of the patient is prepared with an alcohol wipe, and dried. Active electrodes are placed at like points on each side of the paravertebral skin. Upper and lower active electrodes are employed. A ground reference electrode is placed over a bony prominence on the wrist of the patient. Shielded cables are used between the active electrodes and the instrument to minimize induced noise. The patient is instructed to execute the specific motion being examined, while a five second acquisition of EMG signal is obtained. The relative levels of EMG activity are then plotted on an amplitude/time X-Y graph. A baseline graph is recorded with the patient in the neutral position.
Four regions and four motions are assessed in a standard full-spine study. The active electrode placement for each regional exam is as follows:

<table>
<thead>
<tr>
<th>Region</th>
<th>Upper Electrode</th>
<th>Lower Electrode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>C2—1 inch lateral to spinous process.</td>
<td>C7—1 inch lateral to spinous process.</td>
</tr>
<tr>
<td>Upper Thoracic</td>
<td>T1—1 1/2 inches lateral to spinous process.</td>
<td>T6—1 1/2 inches lateral to spinous process.</td>
</tr>
<tr>
<td>Lower Thoracic</td>
<td>T6—1 1/2 inches lateral to spinous process.</td>
<td>T12—1 1/2 inches lateral to spinous process.</td>
</tr>
<tr>
<td>Lumbar</td>
<td>L1—1 1/2 inches lateral to spinous process.</td>
<td>L5—1 1/2 inches lateral to spinous process.</td>
</tr>
</tbody>
</table>

Note: The ground reference electrode is placed on a bony prominence on the wrist of the patient.

The motions to be executed by the patient are as follows:

**Flexion:** The test begins in a neutral position. The patient is instructed to flex, and return to the neutral position.

**Extension:** The test begins in a neutral position. The patient is instructed to extend, and return to the neutral position.

**Rotation:** Both left and right rotation are assessed during one acquisition. This enables the patient to execute a more fluid movement. The results of both left and right rotation appear on the same graph. The test begins with the patient in the neutral position. The patient rotates to the left, then the right, and returns to the original neutral position.

**Lateral Flexion:** The procedure is similar to that of rotation. Both left and right lateral flexion are assessed during one acquisition. The test begins with the patient in the neutral position. The patient lateral flexes to the left, then the right, and returns to the original neutral position.

A full spine examination will result in the production of 16 graphs. A five second acquisition of EMG activity is recorded for each region while executing each motion. If the patient is unable to execute the desired maneuver in this time period, a longer acquisition time may be selected. It is suggested that the patient rehearse each motion several times, with electrodes in place, before the actual test.
INDICATIONS FOR DYNAMIC ASSESSMENT

The authors have previously published specific indications for static surface EMG scanning. We maintain that the static, full spine, seated study is the initial SEMG examination of choice, and should precede any dynamic assessments. The value of dynamic assessment is that it may reveal abnormalities which are not disclosed on the static examination. Therefore, when the static scan fails to disclose abnormality in the region(s) of clinical interest, dynamic assessment may be employed for further characterization of the myodynamics of the patient. Follow up examinations should be performed to evaluate patient response to chiropractic care. Generally, such follow up studies would be performed as part of regular re-exams, typically at 10-12 visit intervals. Follow up exams are indicated until the patterns normalize, or maximal improvement is attained. Equivocal sub-luxation findings, an exacerbation of the patient’s condition, or a new illness or injury justify re-evaluation of clinical need for the test.

INTERPRETATION OF PATTERNS

In chiropractic practice, the primary purpose of SEMG procedures is the quantitative assessment of subluxation-related paravertebral muscle activity. It must be emphasized that SEMG is not a “stand alone” diagnostic technique for a specific clinical entity. Rather, it is a measurement which, when taken in concert with other examination findings, is useful in chiropractic analysis.

Interpretation procedures for dynamic assessments differ from those for static scans. Normative data have been developed for static scans. Interpreting dynamic scans involves different criteria. In flexion, our primary interest is the presence or absence of flexion relaxation, as well as symmetry. In extension, symmetry should be maintained. In rotation and lateral flexion, we examine for a “mirror imaging” of SEMG signal. Examples follow which illustrate these concepts.

REFERENCES


Patient: TEST
SSN: 
date: 07/03/1992, Fri
position: SEATED
action: FLEXION
site: CERVICAL

FIGURE 1. Baseline graph taken with the patient in the neutral position. If the graph indicates excessive noise or poor electrode contact, these conditions should be corrected before proceeding with dynamic acquisitions.
Patient: TEST ROM

SSN: 100-200Hz

Date: 05/31/1992, Fri

position-SEATED  action-FLEXION  site-CERVICAL

FIGURE 2. Flexion with return to neutral. Low potentials are maintained until the return to neutral is initiated. Once return to neutral is accomplished, both channels return to the approximate baseline level. Symmetry of recorded voltages is maintained throughout the action.
FIGURE 3. Extension with return to normal. A smooth pattern of symmetrical activity is observed.
FIGURE 4. Rotation. Note the “mirror imaging” of EMG activity as the patient rotates the head to each side. There is some asymmetry (approximately 50%) of the lower peaks, while the higher peaks are of almost equal amplitude.
Patient: TEST ROM
SSN:
Date: 07/03/1992, Fri
Position-SEATED action-LAT FLEX site-CERVICAL

25 Date: 07/03/1992, Fri
Position-SEATED action-LAT FLEX site-CERVICAL

Solid = Left
Dotted = Right

FIGURE 5. Lateral flexion. "Mirror imaging" with almost identical amplitudes is evident during lateral flexion to each side.
FIGURE 6. Lateral flexion. There is a marked asymmetry of the upper peaks and a lag in return of the left side potentials to the baseline level. Clinical examination revealed evidence of C-1 subluxation.
Dedicated to basic and clinical subluxation-related research.

- Specific Upper Cervical Adjusting in the Supine Position
  Patrick Mathis, D.C.

- Case Report: Upper Cervical Adjusting for Knee Pain
  Mary Brown, D.C.
  Paul Vaillancourt, B.S.

- A Retrospective Study: Patients with Chronic Low Back Pain Managed with Specific Upper Cervical Adjustments
  Shawn S. Robinson, R.T. (ACRRT)
  Karen Feeley Collins, B.A., D.C.
  John D. Grostic, D.C., F.I.C.R.

- Paraspinal Thermographic Analyses: The Effects of an Autonomic Blood Alcohol Challenge
  Harry Wallace, D.C., Joni Wallace, D.C.,
  Joseph Peterson, D.C., Roy Resh, B.S.,
  Robert Wagnon, Ph.D.

- Agenesis of the Odontoid
  Michael D. Millican, D.C.
  Barbara A. Millican, D.C.

- Dynamic Paraspinal Surface EMG: A Chiropractic Protocol
  Christopher Kent, D.C.
  Patrick Gentempo, Jr., D.C.