REVIEW ARTICLE

Surface Electromyography in the Assessment of Changes in Paraspinal Muscle Activity Associated with Vertebral Subluxation: A Review

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Abstract — Electromyography is the technique of recording electrical potentials associated with muscular activity. Needle electrodes may be inserted in the muscle being monitored, or surface electrodes may be placed on the skin overlying the muscles being studied. Both techniques have been used for the examination of paraspinal and peripheral muscle function. However, surface EMG and needle EMG are not interchangeable procedures. This paper reviews the principles of static and dynamic surface electromyographic techniques. Issues of reliability and validity are addressed. The clinical application of SEMG procedures for the assessment of changes in paraspinal myoelectric activity associated with vertebral subluxation are described.

Key Words: Surface electromyography, needle electromyography, vertebral subluxation, paraspinal muscle activity.

Introduction

Electromyographic (EMG) Sampling Techniques

Electrical potentials are produced when muscle contracts. These potentials may be measured and recorded by inserting wire or needle electrodes in the muscle tissue, or by placing surface electrodes on the skin overlying the muscle(s) being evaluated. Needle techniques are frequently used clinically to evaluate abnormalities in peripheral muscle activity, although paraspinal muscles may also be examined in this manner. Such abnormalities may be due to spinal disease, nerve root involvement, peripheral nerve entrapment, or diseases of the muscle itself. Needle electrodes monitor a very small field of myoelectric activity. It is difficult to duplicate the exact depth and location of needle electrode penetration, resulting in inferior reliability. Needle insertion may result in tissue damage resulting in an injury response. In contrast, surface electromyographic (SEMG) techniques are most commonly employed in kinesiological studies, biofeedback applications, and chiropractic analysis. Table 1 summarizes the features of each technique. [1-4]

Surface electrode paraspinal electromyography has been employed since 1948 to investigate the relationship between back pain and muscular activity.[5] Cobb et al[6] reported that pain was more likely to demonstrate change in surface electrode EMG activity than needle EMG potentials. They concluded that "...muscle spasm (even when mild) is accompanied by muscular hyperactivity which can be evaluated by suitable electromyographic techniques. Our data suggest that surface electrodes allow better sampling than teflon coated needles..." and that "...integration procedures (surface EMG) allow better quantification than does the visual evaluation of a (needle) EMG..."

In summary, needle techniques are appropriate for the evaluation of specific muscles, denervation potentials, and myopathies. Surface electrodes are appropriate for kinesiological studies of the global function of groups of muscles.[4] Although needle techniques are more popular than surface electrode techniques, the literature indicates that surface techniques demonstrate superior reliability. In addition to better reliability, the non-invasive nature of the test makes it more appropriate for the evaluation of abnormal recruitment patterns and dysponesis associated with vertebral subluxation.

Reliability

Reliability is a measure of the ability to reproduce a measurement, which is expressed as a coefficient ranging from 0.00 to 1.00. Perfect reliability results in a coefficient of 1.00, while chance agreement would be 0.0. As an example, Hass and Panzer[7] noted that the inter-examiner reliability of palpation for muscle tension is poor, with coefficients ranging from 0.07 to 0.20. As presented below, research data indicates that the reliability of SEMG is clearly superior to palpation for muscle tension.

Surface electrode electromyography with attached electrodes exhibits very good to excellent test-retest reliability. Spector[8] conducted a study at New York Chiropractic College which yielded correlation coefficients ranging from 0.73 and 0.97. Komi and Buskirk[9] compared the test-retest reliability of surface

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Table 1. Characteristic Features of Electromyography (EMG) Using Needle versus Surface Electrodes

Characteristic Features

	Needle Electrodes	Surface Electrodes
1.	More specific; useful in studying single muscles, denervation potentials, and myopathies	Record composite potentials of muscles working together
2.	Invasive	Non-invasive
3.	Difficult to duplicate exact insertion point and depth	Easy to duplicate protocols for longitudinal studies
4.	Act of insertion may elicit insertion potentials	No insertion potentials
5.	Fair test-retest reliability	Very good test-retest reliability

electrodes vs. needle electrodes in the deltoid muscle. The average test-retest reliability for surface electrodes was 0.88 compared to 0.62 for inserted electrodes. Giroux and Lamontagne[10] compared the reliability of surface vs. intramuscular wire EMG of the trapezius and deltoid muscles during isometric and dynamic contractions. The statistical analysis on the integrated EMG was a factorial anlaysis model with repeated measures. They found that surface EMG was more reliable than inserted wire EMG on day-to-day investigations. Andersson et al[11] compared the electrical activity in lumbar erector spinae muscles using inserted electrodes and surface electrodes. They found that the standard deviations and coefficients of variation for wire electrodes was greater than those for surface electrodes. They concluded, "Wire electrodes are more sensitive to electrode location and give estimates with less precision than surface electrodes."

Other investigators have evaluated the reliability of surface electrode techniques using hand-held electrodes. This method is referred to as surface EMG scanning. Thompson et al[12] found that the scanning electrode technique correlated well with the "gold standard" of attached electrode technique. Cram et al[13] evaluated the reliability of surface EMG scanning in 102 subjects in the sitting and standing positions. SEMG scans were performed on three occasions approximately one hour apart on the same day. The median correlation between hand-held and patch electrodes was high, with a correlation coefficient of 0.64. The authors concluded, "With adequate attention given to skin preparation, EMG sensors held in place by hand with a light pressure provide reliable results."

While the preponderance of evidence clearly supports the reliability of SEMG, one negative study has been published. Boline et al[14] investigated the reliability of eight evaluative dimensions of lumbar segmental abnormality. One of the procedures included in the evaluation was surface EMG. The authors concluded that the interexaminer agreement of surface EMG scans was poor. However, the EMG portion of the study has been criticized,[15,16] as the authors used a device with an LED readout, rather than a computer based system such as commonly used in chiropractic practice. Furthermore, the protocol used was at variance with standard methodology. Finally, inappropriate statistical analyses were employed where arbitrary cut-off points were selected for determination of abnormality. These cut-off points were not based on any published normative data study, and no normative data study was provided to support the criteria used. SEMG equipment provides interval data (EMG activity is measured in microvolts). However, the authors chose to use the Kappa statistic for nominal data rather than conventional amplitude measures. Consequently, by using the arbitrary cut-off points, the results were deemed normal or abnormal. As a result of using substandard equipment, atypical protocols, unsubstantiated criteria for abnormality, and inappropriate statistical analyses, the authors failed to support their conclusion.

SEMG and Vertebral Subluxation

Several models and definitions have been proposed for vertebral subluxation. These models have been reviewed elsewhere.[17] A recent definition adopted by the Association of Chiropractic Colleges[18] states, "A subluxation is a complex of functional and/or structural and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health." As Lantz[19] noted, "Common to all concepts of subluxation are some form of kinesiologic dysfunction and some form of neurologic involvement."

Paraspinal muscle dysfunction is generally accepted as a clinical manifestation of vertebral subluxation.[20,21] Traditional chiropractic analysis includes examination of the paravertebral tissues for "taut and tender" muscle fibres. D. D. Palmer expressed the relationship between "tone" and the dynamics of health and disease... "Life is an expression of tone. Tone is the normal degree of nerve tension. Tone is expressed in function by normal elasticity, strength, and excitability...the cause of disease is any variation in tone." [22] Surface EMG provides objective, quantitative data concerning the changes in paraspinal muscle function that accompany vertebral subluxation. Specific clinical applications require an understanding of muscle physiology.

Muscle fibres may be functionally classified as fast twitch and slow twitch fibres. The fast twitch fibres control phasic or fast ballistic movements. Slow twitch fibres are responsible for maintaining tonic postural support.[23] However, the erector spinae muscles present some unique histological and physiological characteristics. One unusual characteristic is that the slow twitch (Type I) fibres are larger in cross section than the fast twitch (Type II) fibres. The large fibres may be recruited at lower forces than the smaller fibres, which is an unusual recruitment pattern. Furthermore, the erector spinae muscles are composed of separately innervated, independently contracting, discrete muscle fascicles. The erector spinae muscles rarely shorten beyond their length in the upright standing position. These factors must be considered when assessing EMG patterns in the erector spinae.[24]

The role of articular mechanoreceptors in producing afferent input to the CNS, and resulting reflex muscle activity, has been investigated. In the context of SEMG assessment of paraspinal muscle function, it has been suggested that articular mechanoreceptors and muscle spindles are activated during the chiropractic adjustment or "manipulation." [25,26] The resulting increase in mechanoreceptor activity is thought to result in reflex inhibition of spastic muscles in the affected area. This increased sensory input is also believed to result in reduced transmission of nociceptive signals, resulting in decreased pain perception.

Type II mechanoreceptors are dynamic, low threshold, and rapidly adapting. These mechanoreceptors fire impulses of less than 500 milliseconds in duration at the onset of tension changes in the joint capsule.[27,28] Experimental evidence demonstrates that Type II articular receptor reflex responses produce changes in the tone of associated muscles when the joint is moved. These reflex changes may be excitatory or inhibitory. It has been shown experimentally that the application of fast manipulative thrusts to the thoracic spine resulted in a brief surface EMG response in the muscles of the contralateral side. However, the application of slow forces showed a gradual, generalized increase in the SEMG activity as the force increased.[29]

Murphy [30] summarized the neurological pathways associated with the maintenance of background postural tone: "Weight bearing disc and mechanoreceptor functional integrity regulates and drives background postural neurologic information and function (muscular) through the unconscious mechanoreception anterior and posterior spinocerebellar tract, cerebellum, vestibular nuclei, descending medial longitudinal fusciculus (medial and lateral vestibulospinal tracts), regulatory anterior horn cell pathway." The anterior horn cells provide motor output which travels via motor nerves to muscle fibres.

Bullock-Saxton, Janda, and Bullock [31,32] have used SEMG techniques to assess subconscious and automatic responses in muscle activation patterns. Janda [33] has suggested that good function of peripheral structures, good muscle balance, and activation of the spinocerello-vestibular circuits facilitates the most important afferent pathways and centers.

Whatmore and Kohi [34] described an important neurophysiologic factor in functional disorders which they termed "dysponesis." Dysponesis refers to a reversible physiopathologic state consisting of errors in energy expenditure, which are capable of producing functional disorders. Dysponesis consists mainly of covert errors in action potential output from the motor and premotor areas of the cortex and the consequences of that output. These neurophysiological reactions may result from responses to environmental events, bodily sensations, and emotions. The resulting aberrant muscle activity may be evaluated using surface electrode techniques. In chiropractic practice, dysponesis may be associated with vertebral subluxation. SEMG techniques, therefore, are used to assess muscular responses to chiropractic adjustments.

Paraspinal EMG Scanning Technique

Protocols and normative data for paraspinal EMG scanning have been published in the refereed literature.[35,36] Hand held electrodes are applied to the skin of the patient overlying the spine at 15 paired sites. EMG signals are measured in microvolts (10^{-6} volts). A computer analyzes these signals, and compares them to a normative data base. In the interpretation of SEMG scans, three factors are considered:

1. *Amplitude.* This refers to the signal level in microvolts. The higher the signal level, the greater the paraspinal muscle activity. By comparing these readings to a normative data base, elevated or decreased signals can be identified.

2. *Symmetry.* This refers to a comparison of the left-right amplitudes at each spinal level.[37]

3. *Frequency shift*. Fatigued muscle exhibits a lower mean or median frequency than non-fatigued muscle.[38-42]

Paraspinal SEMG scans, taken in concert with other examination findings, may be helpful in determining the following:

1. Asymmetrical contraction
2. Areas of muscle splinting
3. Severity of the condition
4. Aberrant recruitment patterns
5. Dysponesis
6. Responses to dysafferentation
7. Response to chiropractic adjustment

Construct Validity

In the absence of a "gold standard" for assessment of the muscular dysfunction associated with the vertebral subluxation complex, the clinical utility of a procedure may be evaluated by determining the ability of the test to perform up to the standards predicted by a theoretical model or construct.[43] In the case of SEMG, the assumption is made that significant changes in SEMG activity will occur following chiropractic adjustment, and that significant changes will not be observed with repeated assessment of controls.

Shambaugh[44] conducted a controlled study where surface electrodes were used to record paraspinal EMG activity pre- and post-chiropractic adjustment. Shambaugh concluded, "Results of this study show that significant changes in muscle electrical activity occur as a consequence of adjusting." In the osteopathic literature, Ellestad et al[45] conducted a controlled study which found that paraspinal EMG activity decreased in patients following osteopathic manipulation. Such changes were not observed in controls in either study. Therefore, these studies support the construct validity of paraspinal SEMG as an outcome assessment for chiropractic adjustment.

Dynamic SEMG

Affixed surface electrodes may be employed for real time assessment of paraspinal muscle activity throughout ranges of motion. Kent and Gentempo have developed a protocol for the dynamic assessment of paraspinal muscle activity in chiropractic practice. A two or four 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 between the active electrodes. The patient is instructed to execute the specific motion being examined, while an 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.

The Flexion Relaxation Phenomenon

Allen[46] observed that when the trunk is flexed, the lumbar paraspinal muscles exhibit EMG activity as eccentric contraction controls trunk lowering. However, when the limit of lumbar flexion is reached, the lumbar paraspinal muscles exhibit electrical silence. It appears that the paraspinal group contracts to support the spine in flexion, but it is believed, at flexion limits, that this support is provided by posterior ligamentous structures rather than active muscles.

As might be expected, Floyd and Silver[47,48] and Pauley[49] 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[50] 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 degrees of flexion, where the trunk was perpendicular to the legs, to the point where the angle formed by the trunk and the legs was 30 degrees. Floyd and Silver reported that in patients experiencing "back-ache," the flexion relaxation phenomenon was absent. In addition, Triano and Schultz[51] 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[52] 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 (i.e., range) 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[53] 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[54] 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[55] reported that during lateral flexion (side bending) the erector spinae muscles demonstrate increased activity on the contralateral side. Wolfe et al[50] 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[56] and Berman and Marcarian[57] 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[58] and Cram[59,23] 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 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 asymmetry (left-right) was measured. Examination of a control group of 40 non-pain subjects found asymmetries ranging from 5% to 10%. Furthermore, Donaldson and Donaldson described two important "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. Since vertebral subluxation may exist without pain, this criterion is useless in the evaluation of asymptomatic patients undergoing wellness or reconstruction care.[60]

If the objective of chiropractic care is the correction of vertebral subluxation, criteria must be developed which reliably evaluate its presence and correction. Alterations in spinal mobility and asymmetrical muscular activity are generally recognized manifestations of vertebral subluxation.[20,21] Therefore, dynamic SEMG studies may be useful in analyzing subluxations as well as discriminating between pain and non-pain populations.

Indications for SEMG

The value of SEMG for measurement of paraspinal muscle activity is its objectivity. It enables the chiropractor to determine areas of abnormal (elevated and/or asymmetrical) muscle function. Thus, the extent of paraspinal muscle dysfunction can be assessed. Follow-up examinations may be used to determine if the patient is responding favorably to the adjusting technique being employed. Furthermore, the procedure may be useful in determining when a patient has reached maximal improvement or "permanent and stationary" status.

The results of SEMG exams are used to aid in designing care plans and setting clinical goals. An examination procedure may be considered "necessary" if:

1. The test is used for clinical assessment, i.e., used to determine the nature of the chiropractic care to be administered.

2. The equipment and protocols are sufficient to insure reliability.

3. More cost effective procedures, that are equally reliable or more reliable, are not available.

Gentempo and Kent have published specific indications for static surface EMG scanning.[61] The examination is indicated if three or more of the following ten abnormalities are present:

1. Palpable paraspinal muscle spasm.

2. Palpable asymmetry of the paraspinal muscles.

3. Asymmetrical range(s) of motion.

4. Paraspinal muscle tenderness.

5. Muscle ache reported by patient.

6. History of trauma to the spine.

7. Diagnosis of nerve root irritation evidenced by abnormal neurological examination findings.

8. Clinical presentation of an antalgic gait or lean.

9. Diminished or asymmetrical paraspinal muscle strength demonstrated by manual or electronic testing.

10. Thermographic evidence of paraspinal muscle dysfunction.

Kent and Gentempo[61] further 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.

In the case of an abnormal static or dynamic SEMG, 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 or 30 day intervals. Follow up exams are indicated until the patterns normalize, or maximal improvement is attained. Equivocal subluxation findings, an exacerbation of the patient's condition, or a new illness or injury justify reevaluation 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 clinical 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 right-left symmetry. In extension, symmetry should be maintained. In rotation and lateral flexion, we examine for a "mirror imaging" of SEMG signal upon changing directions.[61]

Criticisms of SEMG

Some authors have criticized SEMG because of a purported inability to discriminate between patients in pain and non-pain patients. Meeker et al[62] noted a lack of correlation between scanning EMG asymmetries and the presence of low back pain. Dolce and Raczynski[55] concluded that, "...the relation between painful and tender muscles and electromyographic activity are equivocal..." Jalovaara et al[63] disagree, stating "It is concluded that surface EMG is a valid tool for indirectly assessing pain in low back patients but not for classification into different diagnostic groups." Since vertebral subluxations may or may not be accompanied by pain, the issue of correlation or lack of correlation of SEMG potentials with pain is moot for subluxation assessment.

In a comprehensive review of the literature concerning thoracolumbar scanning surface EMG, Meyer[64] correctly notes that some proponents of SEMG have made inappropriate claims. Meyer, however, also suggests that for a diagnostic test to have value, it must identify patients with a specific "target disorder." To responsible clinicians, SEMG is not used as a "stand alone" diagnostic test for any specific entity. Nor is this author aware of any multidimensional index where SEMG is used to determine the presence or absence of a specific disease entity. On the contrary, SEMG is a physiological measurement, such as body temperature or blood pressure. It is not a test for a specific disease, such as a serological test for syphilis. For example, taking a patient's temperature may provide useful information to a physician, even though this test alone cannot be used to diagnose a specific disease. Similarly, elevated blood pressure may be due to several different "target disorders." However, this does not detract from the clinical value of the measurement.

Meyer is critical of the statistical methodology employed by some authors who investigated the reliability of SEMG. Although it is correctly stated that the Pearson correlation coefficient may overestimate reliability, Meyer states that values below 0.75 indicate that a measurement is not reliable. Unfortunately, this is an arbitrary and unsubstantiated standard often not realistically attainable in clinical practice. Haas and Panzer[7] state, "Although interpretation of values between zero and one are somewhat arbitrary, there appears to be consensus that values less than 0.4 represent inadequate reliability." Haas[65] reviewed forty-five original articles addressing the subject of examiner reliability for procedures used in chiropractic analysis (excluding SEMG) and found that few met even this less burdensome standard. Meyer's criticism notwithstanding, few chiropractic analytical procedures can match the reliability of SEMG. The author knows of no alternative assessment for paraspinal muscle tension which approaches the reliability of SEMG.

Meyer correctly notes that the distribution of SEMG potentials is non-Gaussian, and claims that the odds of a normal individual being labeled normal are only 5 out of 1000 after a full spine SEMG. This is inconsistent with both clinical experience and common sense. The authors of the three normative data studies cited by Meyer never claimed a Gaussian distribution. Sackett et al[66] observed that "...diagnostic test results simply do not fit the Gaussian distribution (actually, we should be grateful that they do not; the Gaussian distribution extends to infinity in both directions, necessitating occasional patients with impossibly high hemoglobin values and others on the minus side of zero!)." Again, the fever and blood pressure analogies are useful. Meyer has resorted to a "straw man" argument, based upon a presumed Gaussian distribution never claimed by the authors of the papers being criticized.

It is important to note that Meyer's review of literature is dated. Medline sources were limited to 1989 through April 1993, while only the years 1980-1991 were included from the Index to Chiropractic Literature. Given the shortcomings of this review, it is not surprising that the authors of a more recent review disagree with Meyer's conclusions. Lofland et al[67] state that "Recent methodologically sound research has shown modern multichannel surface EMG to be reliable and valid."

Misleading Use of Literature and Guidelines

The clinical use and third-party reimbursement of SEMG has raised some controversy which revolves around methods of technology assessment. Objective assessment of a technology requires a comprehensive review of literature. Citing only references which support a particular position is advocacy, or "curve fitting," not science. Unfortunately, such selective reviews of literature have been used in the development of certain clinical practice guidelines,[68, 69] which, in one instance,[68] resulted in a rating of scanning surface EMG with hand-held electrodes as "investigational" and a rating of electrode SEMG of "promising." In sharp contrast to the conclusions reached when "curve fitting" is the method of literature reference selection, another set of chiropractic practice guidelines,[70] which included a comprehensive review of the literature, gave SEMG an "established" rating, which is the highest rating possible. Despite this, the "investigational" and "promising" ratings have been cited as a basis for denying reimbursement for chiropractic SEMG procedures.

Another case of improper use of literature is the inappropriate application of position papers and technology assessments. For example, the American Association of Electrodiagnostic Medicine published a position paper on the use of surface EMG techniques limited to the diagnosis and treatment of a narrow range of disorders including neuronopathies, radiculopathies, plexopathies, neuromuscular junction disorders and myopathies.[71] It is explicitly stated that, "This paper does not comment on the use of SEMG in the diagnosis of central nervous system disorders, problems with coordination, fatigue, psychological disorders or pain as an entity independent of nerve damage...It addresses the use of surface EMG in one area only and its application, if any, to the practice of electrodiagnostic medicine. This statement is not intended to address all possible uses of, or issues regarding, surface EMG and in no way reflects on the usefulness of surface EMG in those areas not addressed." Despite the clarity of this position paper, parts of it have been cited out of context to deny reimbursement for chiropractic SEMG procedures which are not addressed in the document.

Conclusion

Paraspinal EMG scanning is a reliable tool for the quantitative assessment of paraspinal muscle activity. This technique, by virtue of its non-invasive application, is well adapted to chiropractic analysis, particularly in relation to recording altered paraspinal muscle activity. This use of surface EMG is of specific interest since aberrant muscle activity is generally accepted as one manifestation of vertebral subluxation. This procedure has been demonstrated to be reliable, thus supporting its usefulness within the spectrum of chiropractic analyses. In addition, the information gained through paraspinal EMG scanning may be effectively used as an outcome assessment for chiropractic care.

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