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The integration of surface electromyography in the clinical decision making process: a case report

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Objective: *To demonstrate how the findings of surface electromyography (S.E.M.G.) were integrated into the clinical decision-making process.*

Clinical Features: *This is a retrospective review of the file of a 27-year-old male suffering from mechanical low back pain. He was evaluated on 3 separate occasions over a 3 year period. History, radiography, functional outcome studies, visual-numerical pain score, pain drawing, physical examination and surface electromyography were utilized in evaluating this patient.*

Intervention and Outcome: *The two clinical interventions of spinal manipulative therapy (S.M.T.) had positive results in that the patient achieved an asymptomatic state and returned to his position of employment. The S.E.M.G. data collected during the industrial assessment, did not provide the outcome that the patient had anticipated.*

Conclusion: *Surface electromyography is a useful clinical tool in the author's decision-making process for the treatment of mechanical lower back pain. Therapeutic intervention by S.M.T., therapeutic exercises and rating risk factors were influenced by the S.E.M.G. findings.*

(JCCA 1998; 42(1):21–34)

Objectif : *Démontrer de quelle façon les données de l'électromyographie de surface (E.M.G.S.) ont été intégrées au processus de prise de décision clinique.*

Tableau clinique *: Il s'agit de l'analyse rétrospective du dossier d'un jeune homme de vingt-sept ans souffrant de douleurs lombaires basses mécaniques. Il a fait l'objet de trois évaluations différentes sur une période de trois ans, à l'aide de différentes méthodes : analyse des antécédents, radiographie, études de l'évolution fonctionnelle, cote visuelle-numérique de la douleur, croquis de la douleur, examen physique et électromyographie de surface.*

Intervention et évolution : *Les deux interventions cliniques effectuées par thérapie spinale manuelle (T.S.M.) ont donné des résultats positifs, étant donné que le patient a retrouvé un état asymptomatique et a pu reprendre le travail. Les données de l'E.M.G.S. recueillies durant l'évaluation réalisée sur le lieu de travail n'ont pas provoqué le résultat auquel le patient s'attendait.*

Conclusion : *Pour l'auteur de cet article, l'électromyographie de surface constitue un outil clinique efficace dans le processus de prise de décision clinique en ce qui a trait au traitement des douleurs lombaires basses mécaniques. Les résultats de l'E.M.G.S. ont eu une influence sur l'intervention thérapeutique par T.S.M., les exercices thérapeutiques et l'estimation des facteurs de risque.*

(JACC 1998; 42(1):21–34)

KEY WORDS: surface electromyography, clinical decision-making, mechanical low b--k pain.

MOTS CLÉS : électromyographie de surface, prise de décision clinique, douleurs lombaires basses mécaniques.

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Introduction

The use of surface electromyography in chiropractic practice primarily focuses on the areas of:

1 A kinesiological study of surface muscles.
2 Neurophysiological studies of surface muscles, and
3 A time force relationship of surface electromyographic signals.[1,2]

In recent years the chiropractic use of S.E.M.G. has been primarily to objectify muscle damage or impairment and to classify the severity of types of impairment in muscle function. This can be accomplished by:

1 Measuring the magnitude of myoelectric activity and the symmetry of the myoelectric signal when compared with similar muscles of the non-involved side.
2 Assessing the kinesiological function in a dynamic mode for specific tasks.

This measurement technique allows the chiropractor to objectively monitor patient progress and the effectiveness of his or her treatment protocol by observing changes in magnitude and symmetry of the S.E.M.G. signal. It can also play a major role in the clinical decision making process, albeit a limited role, consistent with the limitations inherent to this technology.

The "Clinical Guidelines for Chiropractic Practice in Canada" includes the following ratings for S.E.M.G.: 1. Static S.E.M.G. (surface scanning) has received a rating classification of investigational with an evidence class level of 2 and 3; whereas, 2. Dynamic S.E.M.G.s (with fixed electrodes and used during a simple postural task) received a rating of promising with an evidence class level of 2 and 3. This is the second highest level of evidence that is available for a clinical test.[3]

The CCA Guidelines have rated "fixed" electrodes or "dynamic" S.E.M.G. testing for asymmetric or hypertonic muscles "equivocal" with an evidence class level of 1, 2 and 3.[4] For scanning or non-fixed, hand held electrodes, the CCA Guidelines have provided a rating of investigational with an evidence class level of 2 or 3.[4]

Consequently, the clinician who approaches practice in an evidence-based manner is confined to fixed electrodes and dynamic S.E.M.G. The purpose of this paper is to show how the use of dynamic S.E.M.G. can play an integral part in the clinical decision-making process.

The author has attempted to utilize (where reasonable and practical) the units, taxonomy and standards in the reporting in this paper that approach/meet the recommendations of the ad hoc committee of I.S.E.K. August 1980.[5]

Patient preparation protocols were consistent with those of Cram[6] and Basmajian.[7]

Electrode placement and size was consistent with the findings of Winter.[8]

The Quality Assurance program utilized was the "draft form" of the Quality Assurance program published in JCCA by Nicholson, Dainty and Marcarian.[9]

The surface electromyography (S.E.M.G.) system utilized for this study was an eight channel MyoVision 3000 Plus. It utilized a 25–500 Hz bandpass filter with a high performance 60 Hz notch filter. The S.E.M.G. signal was amplified and analog to digital conversion was performed with a 10 bit resolution. The signal was then digitally rectified and low pass filtered in order to provide a graph which displayed the "envelope" of muscle activity.[10,11] Data was then transferred to the computer for display and storage. Eleven millimetre diameter disposable E.C.G. attached electrodes were utilized.[8]

The author would like to caution the readers in respect to his statements concerning lateral flexion and rotation. There is an inadequate S.E.M.G. data base in respect to lumbar lateral flexion and rotation and as a consequence statements and conclusions made in respect to lateral flexion and rotation are primarily predicated upon clinical experience and observation in the author's practice.

Case report

Patient contact #1

A 27-year-old male was referred for evaluation in late 1993 by his family physician. His presenting complaint was of acute mechanical lower back pain with pain radiating down the right leg to his greater toe. This was accompanied with paresthesias, and aggravated by movements which would create pain of a sharp, jabbing nature. His symptoms were of 1 year in duration. His present medication was 292's with codeine. The patient maintained that this injury was consequential to a fall off a ladder in 1992. The patient had earlier been assessed by an orthopaedic surgeon as well as at a W.C.B. Hospital. At the time of our assessment, the patient provided scores of 1 on his Wiltse Pain Drawing, a Revised Oswestry Low Back Pain and Disability Score of 64%, and a Visual-Numerical Pain

Score of 8. On further examination there was some painful restriction in all lumbar ranges of motion. There were no neurological deficits of either lower extremity.

A review of his lumbar x-rays which were completed at his local hospital in September, 1992, revealed a grade 1 (Meyerding) L5 spondylolisthesis. There was noted the presence of small Schmorrl's nodes at L3, L2, and L1 as well as failure of closure of the posterior arch of S1 (Spina bifida). No degenerative changes were apparent.

A surface electromyographic evaluation was carried out on this patient in the ranges of flexion/re-extension, right and left lateral flexion and left and right rotation. Patient preparation in all S.E.M.G. tests was consistent with skin preparation protocols of Basmajian[7] and Cram.[6] Two channel electrode placement was lateral to L4–L5, and L3–L4 interspace by 2 centimetres[8] and oriented longitudinally over the erector spinae muscles. A quality assurance program as recommended by Nicholson, Dainty and Marcarian is observed in all S.E.M.G. testing.[9]

By reviewing Figure 1A, it can be seen that in the flexion/re-extension the initial "peak" is reflective of the forward flexion of the patient, followed by the "valley" which is reflective of full forward flexion. The second peak is reflective of the re-extension phase to the standing neutral position. The subsequent "plateau" was substantially elevated. It should have a level of myoelectric activity under 7 microvolts[12] but when this particular patient returned to his neutral standing position, the level was between 30 and 40 microvolts bilaterally and consistent with his starting level. This was evidenced on all 3 trials. The subsequent small "peak" is again a return to flexing with a subsequent full flexion value in the "valley" of approximately 15 microvolts and then a re-extension again to 80 microvolts. Figure 1A shows that the patient has an extremely elevated level of myoelectric activity while standing in the erect posture and the magnitude is greatly increased in all positions.[12] Although there is a good relaxation phase between flexion and re-extension, his failure to return to a microvoltage of less than 7 microvolts in the erect phase is consistent with the co-contraction of the muscles bilaterally.[12]

Figure 1B is reflective of left and right lateral flexion in which Marker Bars 1 and 5 reflect left lateral flexion and a return to neutral in Marker Bars 2 and 6. Marker Bars 3 and 7 are reflective of right lateral flexion and a return to neutral posture in Marker Bars 4 and 8. In this graph, there is a high magnitude of myoelectric activity, and also disturbance of the normal symmetry of myoelectric activity and recruitment of these muscles. This conclusion is consistent with published data.[13]

Figure 1C relfects the myoelectric recruitment patterns and magnitude of the myoelectric activity in the lumbar spine during left and right rotation. Marker Bars 1, 2, and 5, 6 reflect left rotation whereas Marker Bars 3, 4, and 7, 8 reflect right rotation. The symmetry reflected in this chart is more acceptable but the magnitude is still substantially elevated. Published data by Nouwen et al. support this conclusion in respect to patterns.[14]

Discussion

It is not an unusual presentation in our chiropractic office to have a patient with these symptoms and signs. The disturbances in range of motion were confirmed by the obvious high level of myoelectric activity in the muscles and the co-contraction (spasm) of the para-spinal musculature. The use of surface electromyography in the clinical decision making process assisted with the prescription of a home therapeutic exercise program which addressed the lumbar musculature – (pelvic tilts, lateral flexion, and modified trunk flexion). When the therapeutic exercise program was combined with spinal manipulative therapy, the patient reported 50 percent improvement after the second treatment. Because of the congenital defects and the myo-electrical disturbances in the lumbar spine of this young man, it was recommended that he maintain a home therapeutic exercise program on an indefinite basis. Subsequent to his 4th spinal manipulative therapy, he was asymptomatic and was discharged from our care.

Patient contact #2

In February, 1996 this patient was referred to our office by the Human Resources Department of his employer for evaluation. The suitability of this patient for a specific task was an issue of dispute between management and union. The patient was requesting a move to a heavy repetitive lifting area (with an associated shift premium) but management felt the patient was not suitable for this demanding work. At that time the patient signed an informed consent form as recommended by the Canadian Chiropractic Protective Association (CCPA)[15] and he also signed a form allowing for the release of medical information in his file to his employer, his family physician and his union.

Patient: ID: Date: Oct 06, 1993
Procedure Name: lumrom Screen Title: Flexion/Extension
Data File Name:

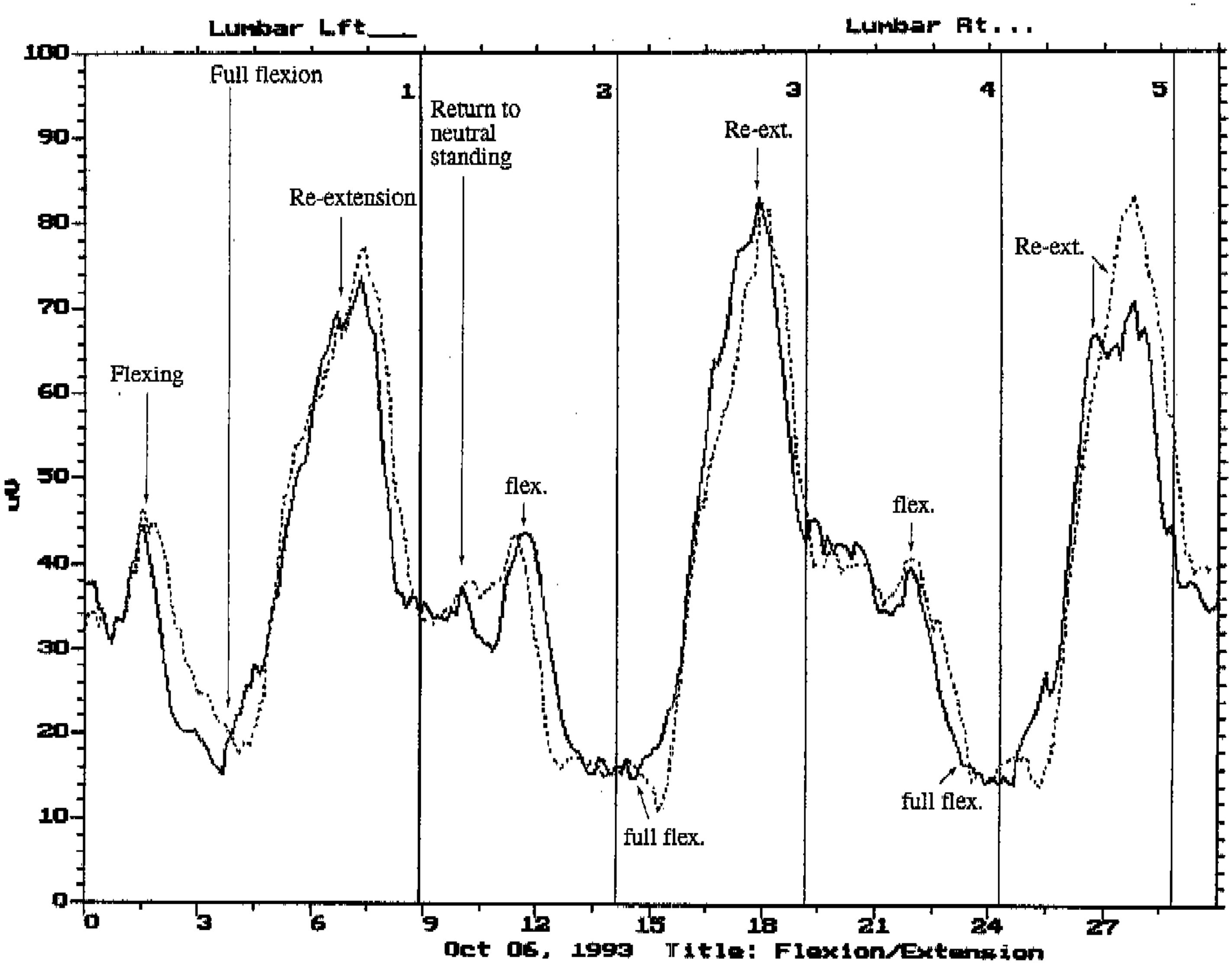

Figure 1A: 1. Note elevated levels at neutral standing posture

Patient: ID: Date: Oct 06, 1993
Procedure Name: lumrom Screen Title: L/R Lateral Flexion
Data File Name:

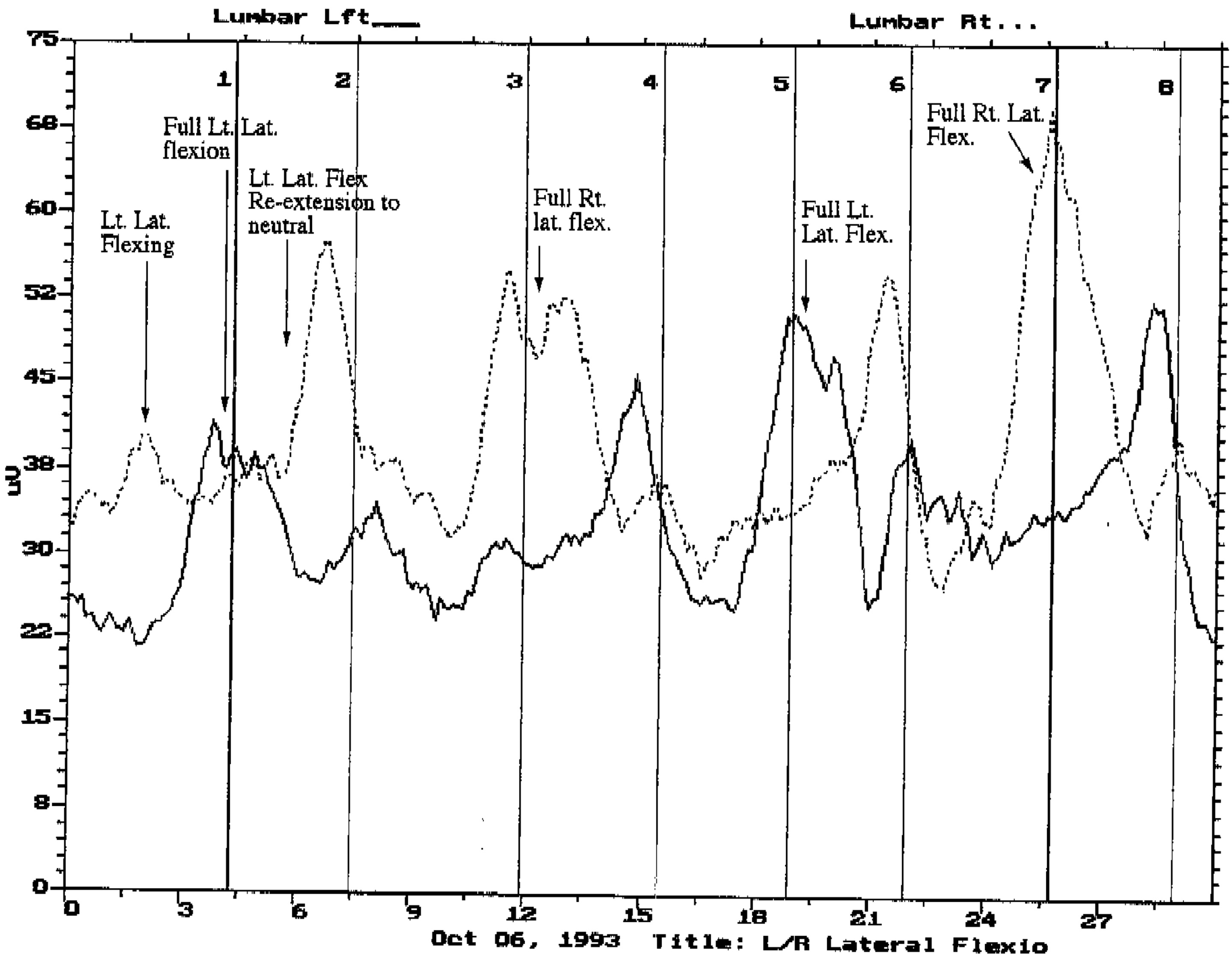

Figure 1B: Marker Bars:
1 – 5 Lt. Lat. Flexing
2 – 6 Return to neutral from Lt. Lat. Flexion
3 – 7 Rt. Lat. Flexing
4 – 8 Return to neutral from Rt. Lat. Flexion

Patient: ID: Date: Oct 06, 1993
Procedure Name: lumrom Screen Title: L/R Rotation
Data File Name:

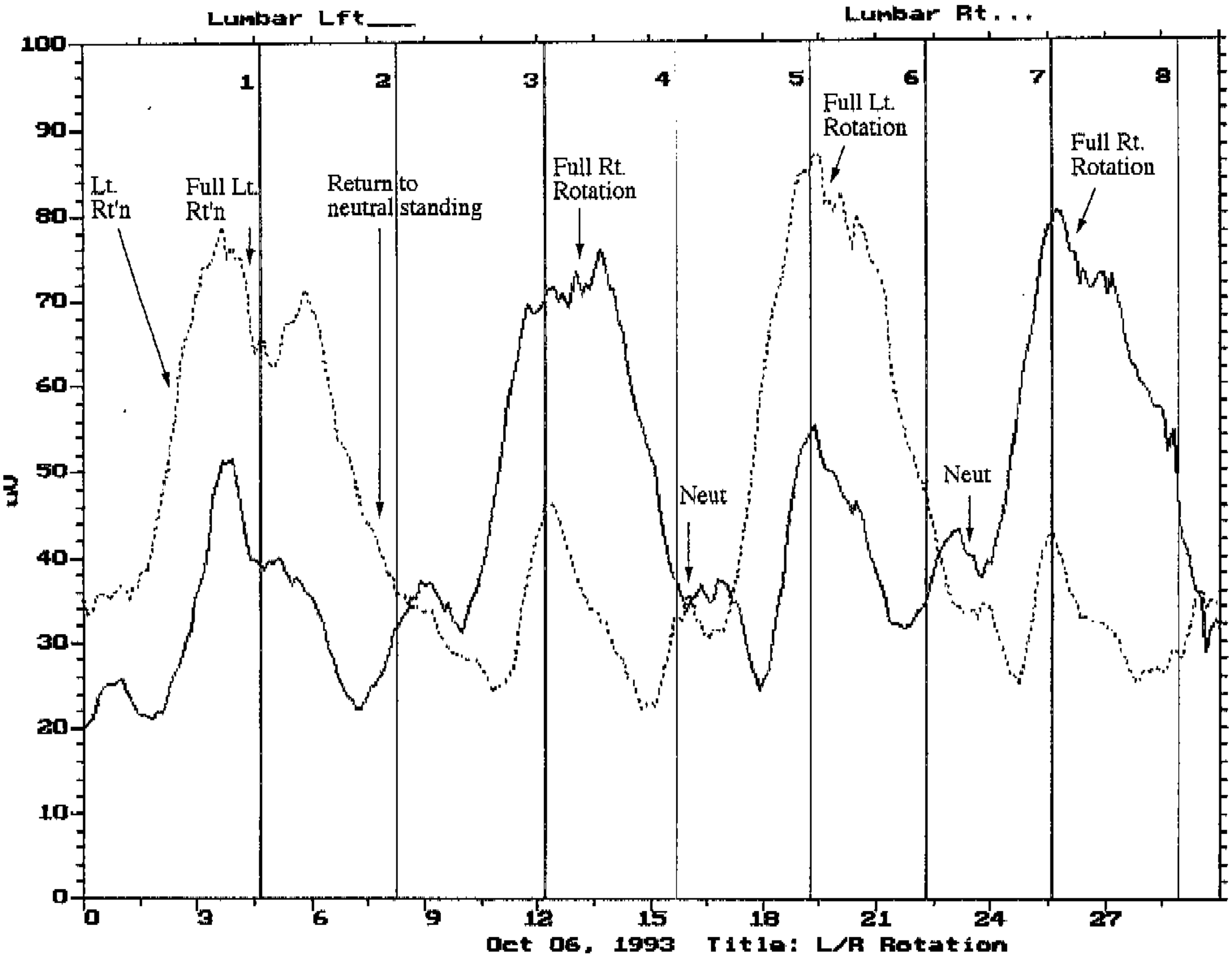

Figure 1C: Marker Bars: 1 – 5 Lt. Rotation
2 – 6 Return to neutral from Lt. Rotation
3 – 7 Rt. Rotation
4 – 8 Return to neutral from Rt. rotation

The terms of reference for this consultation were to identify the risk factors were he to be assigned to an area which required repetitive lifting of approximately 28 racks of 16 objects per rack, per 12 hour shift with each object weighing approximately 35 pounds. This is approximately 15,680 pounds per shift in 35 pound increments.

A subsequent case history and examination was carried out on this 30-year-old man. At this time he reported a Visual-Numerical Pain Score of 1, a Low Back Pain and Disability Index (Revised Oswestry) of 0.00 percent, a Roland-Morris Index of zero and a Wiltse Pain Drawing with a score of 1. He had no outstanding restrictions in any ranges of motion and all relative neurological reflexes were normal. It was felt that a further radiographic evaluation at this time could not be justified because of a lack of symptomatology of the patient and an earlier x-ray examination had already disclosed the congenital/acquired anomalies.

Surface electromyography tests were completed again on this patient and those tests included a flexion/relaxation test, a S.E.M.G. "range of motion" evaluation (flexion/extension, lateral flexion, rotation) and a special exam to simulate the proposed work at his employment. The Human Resources Department had supplied us with a 35 pound object as well as a 55 pound object which they manufacture. The special test involved the patient lifting the 35 pound object from the floor under skid-like conditions to standing up with the object at waist height, turning, taking 2 to 3 steps forward and placing the 35 pound object on a waist high table which was to simulate conveyer-like conditions. The patient then had to return to the standing position. Subsequently the patient had to lift a 35 pound object off the simulated conveyer, walk 2 to 3 steps and then place the 35 pound object on the floor, then stand up, and return to the original standing position. This test was repeated several times using both the 35 pound and 55 pound objects. Patient preparation protocols and electrode placement protocols were consistent with those respected in patient contact #1.

In the flexion/relaxation test, the patient demonstrated 20 percent greater myoelectric recruitment level in the left lumbar para-spinal musculature when compared to the right.

His flexion/relaxation ratios were 1.67 and 1.93 in the left and right musculature respectively. Normal subjects demonstrate ratios greater than 3.2, while symptomatic patients produce ratios less than 1.8.[12] Between 1.8 and 3.2 is a borderline area.[12] According to these tests the patient had an unexpected or abnormal ratio in the left lumbar musculature with a borderline ratio in the right lumbar musculature. In 1993, the software was not formatted for the data analysis of the patient's S.E.M.G. signal and therefore the ratios and percentage difference between left and right for the 1993 tests are not available.

The averaged magnitude of myoelectric activity that was recruited in the left lumbar musculature was 11.66 uv and in the right, 3.57 uv.[12]. Generally, normal findings are below 7.0 microvolts while findings greater than 14 microvolts are deemed abnormal. Between 7 and 14 microvolts are regarded as borderline.[12] The left lumbar musculature was showing a borderline level of myoelectric activity recruitment. (See Figure 2A).

Figure 2B simulates left and right lateral flexion with left lateral flexion being Bars 1, 2 and 5, 6 and right lateral flexion being Bars 3, 4 and 7, 8. There is considerable disruption in symmetry with right lateral flexion being more acceptable than the left lateral flexion in respect to symmetrical patterns.[13,14]

In Figure 2C, Bars 1, 2 and 5, 6 show the recruitment patterns and magnitude of left rotation and right rotation for Bars 3, 4 and 7, 8. The magnitude and the symmetry is acceptable in rotation.[14,16] These two former tests in Figures 2A, 2B and 2C were accomplished using two channels of a 4 channel S.E.M.G.

In the special examination which was to simulate a "skidding up" process of 35 pound object, four channels of an eight channel S.E.M.G. were used. The bars 1–9 in Figure 3A simulate the changes in activity associated with the earlier delineated lifting program. The upper graph represents the monitoring of the upper erector spinae at the L1, L2 level whereas the lower graph depicts the myoelectric activity that was recorded at the L4, L5 area. In the upper erector spinae, it is fairly obvious that there is excellent symmetry (save where there was rotation) in both groups of the para-spinal musculature. In the lower lumbar spine, the myoelectric recruitment patterns show substantially more myoelectric recruitment of the left lower musculature when compared to the right. The myoelectric magnitude of the left musculature varies between 50 and 100 percent greater level of myoelectric activity, depending upon the activity involved in the tasks. This test was duplicated on multiple occasions to show

Test performed by: DR. NICHOLSON/ Page 1 of 1
SUITE 1A 578 KING ST. MIDLAND ONT. L4R 4P3
1-705-526-6221

Patient: ID: Date: Feb 06, 1996
Procedure Name: lumflex Screen Title: Lumbar Flexion
Data File Name:

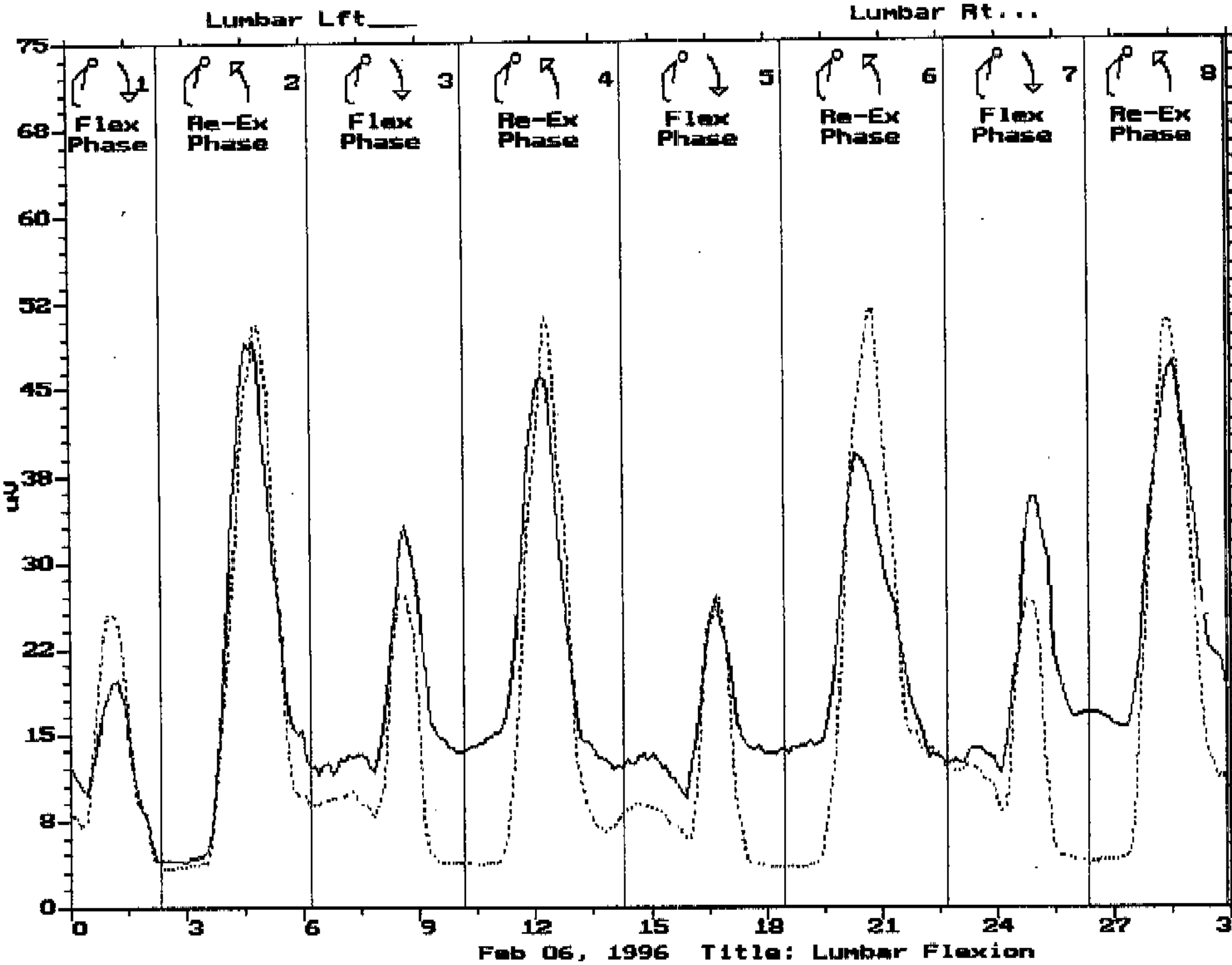

Figure 2A: Markers 1, 3, 5, 7 –> Flexion
Markers 2, 4, 6, 8 –> Neutral

Note elevated levels (uv) of left musculature
Repetitive motion appears to aggravate left musculature but essentially makes no change to recruitment patterns of right musculature. Compare to 1993 Amplitude (Figure 1A).

Patient: ID: Date: Feb 06, 1996
Procedure Name: lumrom Screen Title: L/R Lateral Flexion
Data File Name:

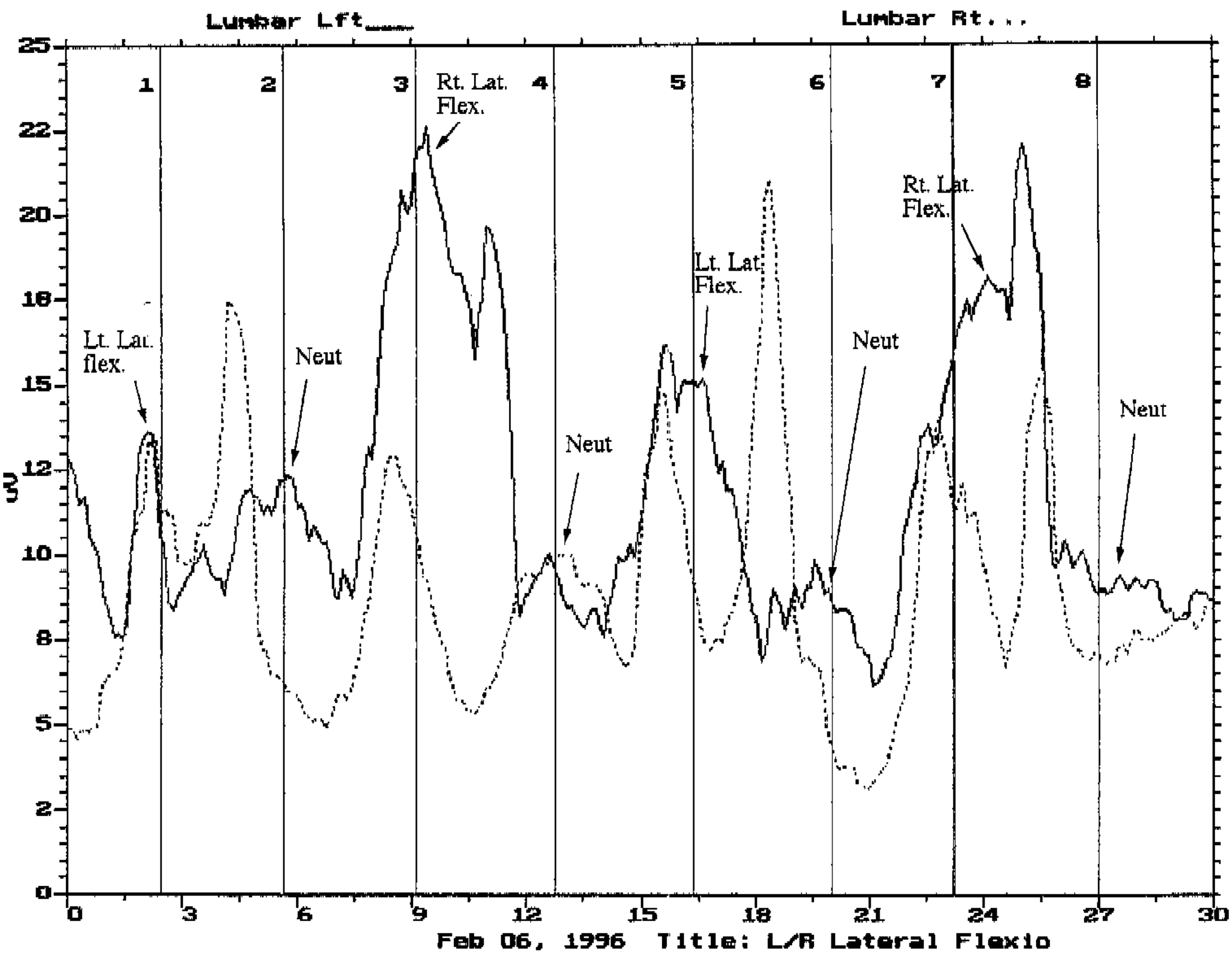

Figure 2B: Marker Bars: 1 – 5 Lt. Lat. flexion
2 – 6 Returning to neutral from Lt. Lat. Flexion
3 – 7 Rt. Lat. Flexion
4 – 8 Returning to neutral from Rt. Lat. Flexion

Note the "craginess" of the left muscle activity "envelope" when compared to the Rt. muscle activity envelope. Reflective of disturbed "firing patterns". Compare amplitude to 1993 test (Figure 1B).

Patient: ID: Date: Feb 06, 1996
Procedure Name: lumrom Screen Title: L/R Rotation
Data File Name:

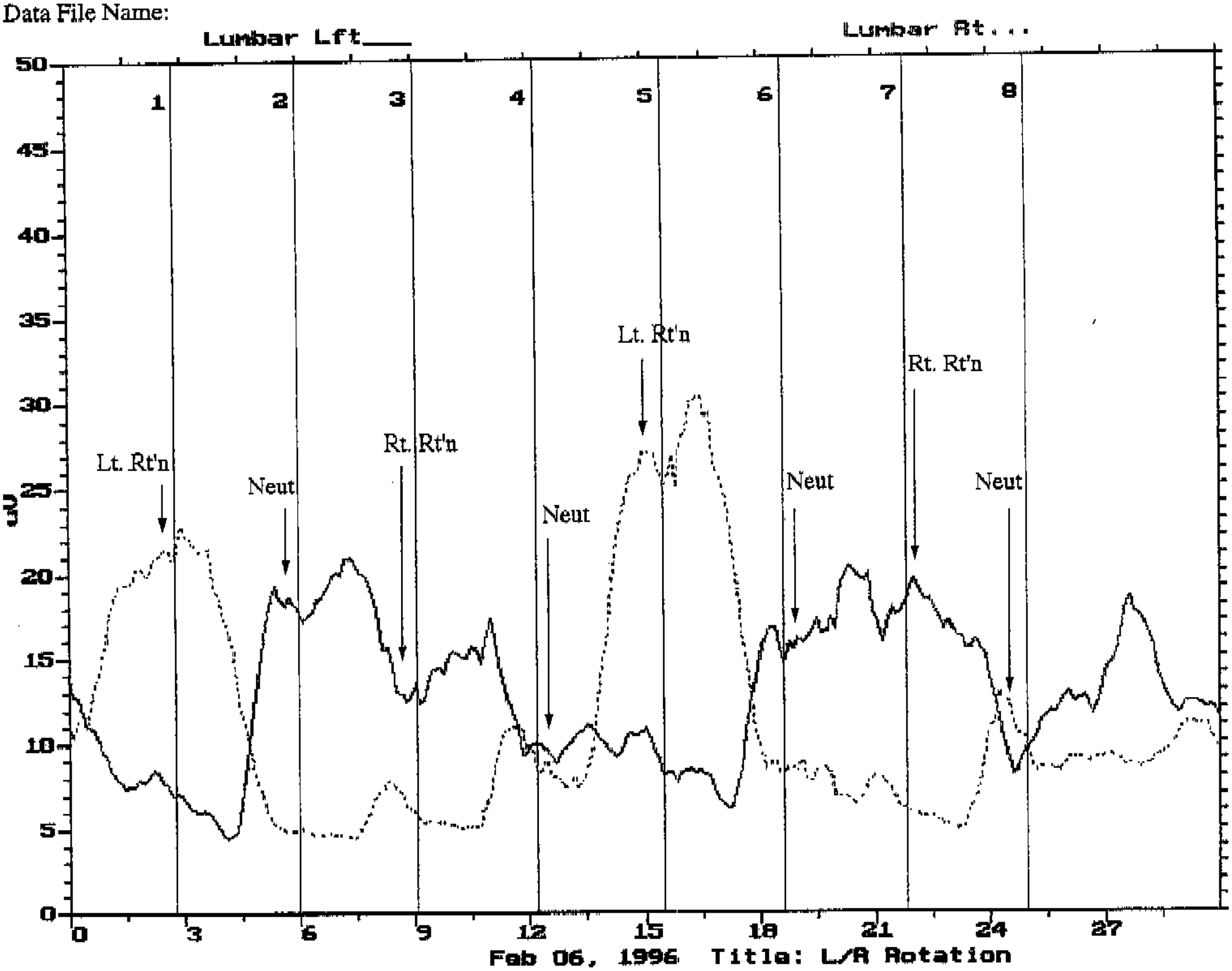

Figure 2C: Marker Bars: 1 – 5 Lt. Rotation
2 – 6 Return to neutral from Lt. Rotation
3 – 7 Rt. rotation
4 – 8 Return to neutral from Rt. Rotation

Compare to 1993 Amplitude (Figure 1C).

consistency of the discrepancy of myoelectric activity recruitment magnitude.[11]

The same test was then completed using a 55 pound object. In lifting a 55 pound object, the same conclusions can be drawn for this patient. See Figures 3A and 3B.

Predicated on the foregoing, the risk factors that were identified in this patient in respect to his lumbar spine were:

1 A past history of chronic low back pain.
2 Radiological evidence of pre-existent congenital/acquired factors (Grade 1 spondylolisthesis and Schmorrl's nodes).
3 Abnormalities in the flexion/relaxation test (ratios, asymmetry, and magnitudes)
4 Discrepancies in the S.E.M.G. lateral flexion and rotation tests and substantial differences of symmetry and magnitude in the S.E.M.G.s of the simulated work conditions of lifting 35 and 55 pound objects.

Discussion #2

It was the opinion of the author that the patient was demonstrating numerous biomechanical deficiencies in his lower lumbar spine and did not demonstrate the necessary biomechanical capacities to perform continued heavy, repetitive lifting. As a consequence of this, the Human Resources Department was advised that for this patient to assume the handling of this number (28 × 16 × 35 pounds) of objects per shift per day would put him in a position for potential serious injury.

Consequently, the surface electromyography tests played an integral part in asse ·ing this patient's physiological capacity to fulfil the requirements of a change in his daily activities at work.

Patient contact #3

Two months subsequent to the industrial assessment, the family physician of the patient again referred the patient to our office for consultation and evaluation. Subsequent to the reporting to the industry, the industrial employer *did not* move its employee to his requested area for heavy, repetitive lifting. The union and the patient had agreed to our recommendation. The physician had again referred the patient to our office with a chief complaint of acute lower back pain which was central at the lumbo-sacral junction and was aggravated by coughing, sneezing or any increase in abdominal pressure. He had bilateral paresthesias in both limbs and maintained that his low back pain was aggravated by lifting and twisting. He said this pain had been persistent for the preceding 3 nights after working on his car at home in his garage. At this time, the patient's primary concern was that he may potentially qualify for a longterm disability pension. One must keep in mind that this is the same patient that 2 months prior was insisting that he had no difficulty with his back any more and could enter into a repetitive, heavy lifting area at work. Further it had now been announced that the employer was "closing down."

Because of the mechanical low back pain symptomatology with which he presented, it was a consideration that there may be a compromised intervertebral disc, as his signs and symptoms were consistent with a contained nuclear herniation. It was the author's opinion that the patient should enter into a discussion with the family physician and/or orthopaedic surgeon as to alternatives for his ongoing, debilitating back problems. There were noticeable psycho-social aspects in respect to the patient's presenting circumstances. The patient repetitively queried about a longterm disability pension especially since "the plant" was closing down.

During the interim, while the patient was discussing surgical alternatives and arranging orthopaedic consultation, the patient agreed to a therapeutic trial with an informed consent of the potential hazards associated with his mechanical lower back pain. Subsequent to the consultation, further radiographic examination was not warranted as plain film radiography would not disclose the presence or absence of a contained nuclear herniation. It would be unwarranted to expose the patient to radiation where no requisite benefit could be acknowledged. With informed consent and the patient fully aware of the hazards associated with a contained nuclear herniation, we agreed to do a therapeutic trial of spinal manipulative therapy and electrotherapeutics. By the 4th intervention, the patient was reporting considerable improvement and by the 6th spinal manipulative therapy, the patient felt that he was now capable of returning to work. The patient was seen after 1 day of work and the patient was at this time totally asymptomatic. This was 10 days subsequent to the consultation and our 7th intervention with this patient.

Conclusion

Surface electromyography is not a "stand alone" proce-

Patient: ID: Date: 1996
Procedure Name: skidup35 Screen Title: skid up-down 35lbs
Data File Name:

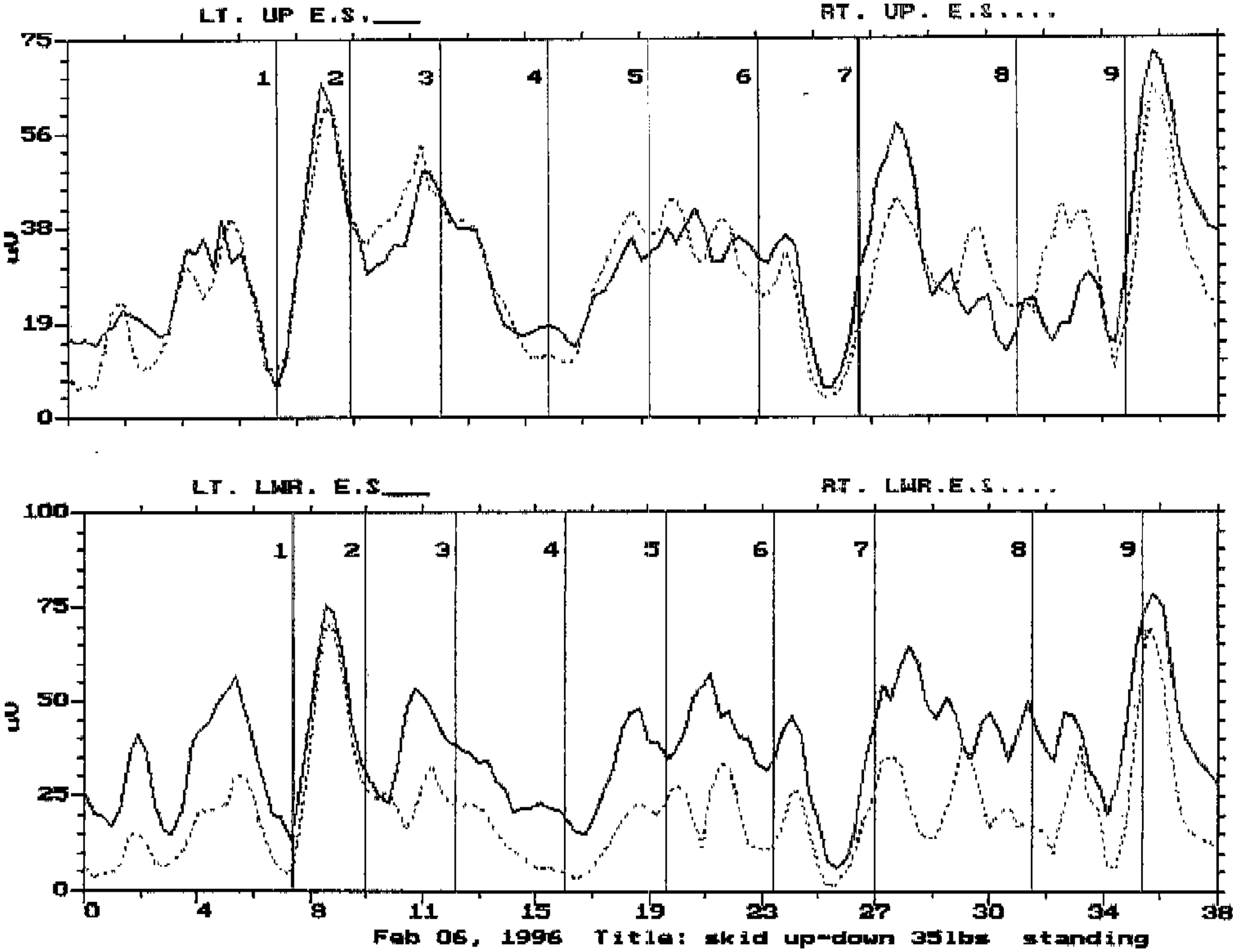

Figure 3A: Marker Bars:
1. Bending down to pick up object (knees bent)
2. Pick up object and stand erect
3. Turn
4. Walking 3 steps
5. Flexing and putting object on table
6. Re: extension and waiting, standing (3–4 secs)
7. Picking object up off table
8. Turning and walking
9. Flexing and placing object on floor (bending knees)

Last frame: Re: extension to neutral posture

Patient: ID: Date: 1996

Procedure Name: skidup55 Screen Title: SKID UP-DOWN 55

Data File Name:

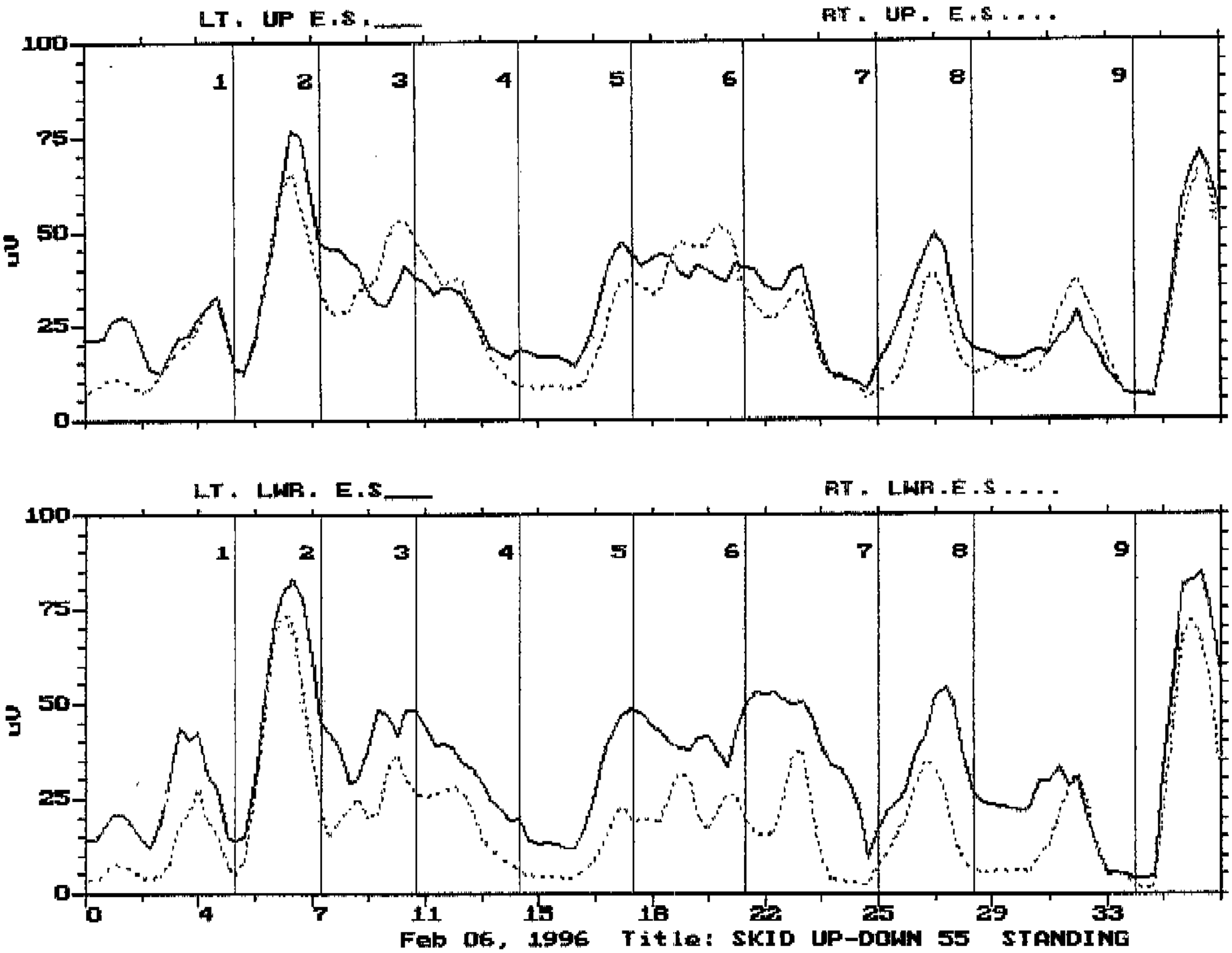

Figure 3B: Marker Bars: 1. Bending down to pick up object (knees bent)
2. Pick up object and stand erect
3. Turn
4. Walking 3 steps
5. Flexing and putting object on table
6. Re: extension and waiting, standing (3–4 secs)
7. Picking object up off table
8. Turning and walking
9. Flexing and placing object on floor (bending knees)

Last frame: Re: extension to neutral posture dure in a clinician's armamentarium of clinical procedures. In this particular case which covers 3 years and 3 separate interventions, S.E.M.G. was an influencing factor in the author's clinical decision making process on two of the occasions. With the first contact in late 1993, S.E.M.G. influenced the author's prescription of a home therapeutic exercise program addressing the specific exercises and the duration that the exercise program should be maintained. In the second contact, for the author it has been a highly useful diagnostic aid in the objectification of soft tissue performance more consistent with physiologic assessment to discern the presence or absence of a risk factor in kinesiologic performance of a work place activity. Ultimately the utilization of S.E.M.G. with this particular patient helped the author to identify an area of weakness that may have lead to a compensable injury in the work place if the patient had been allowed to assume the proposed position of repetitive heavy lifting. In consideration of the biomechanical and kinesiologic problems existent in this patient's lumbar spine, it has been an important assessment tool for use as a therapeutic planning indicator, and a measure for medical/legal/insurance objectification.

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