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XI. Low Back Pain

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Low Back Pain Assessment, Prevention, and Rehabilitation

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Sponsor: *National Institute of Handicapped Research*

Purpose—The goal of our program has been to improve the adequacy of present techniques of physical and psychosocial assessment of low back pain patients, especially in regard to the contribution of adequate assessment to rapid rehabilitation following injury, and the prevention of chronicity.

Progress—During the past year several projects have resulted in published and submitted papers on: 1) the development of a standardized physical examination rating scale for the quantification of somatic amplification; 2) preliminary reliability and validity testing of the Somatic Amplification Rating Scale (SARS); 3) the development of a unique paper-and-pencil

measure for assessment of a patient's attitudes and beliefs regarding chronic pain management after viewing a standardized informational videotape; 4) the prevalence of cognitive deficits in chronic pain patients with and without documented head/neck injuries; 5) the concurrent validity of patient pain drawings as an assessment tool; and 6) the utility of the Symptom Checklist-90-R as a psychological assessment instrument with low back pain patients.

Other ongoing projects include exploration of the psychophysiological correlates of improvement in low back pain patients, as well as attempting to further our use of functional assessment of physical abilities and limitations, especially in regard to worksite requirements.

Biomechanics: Effects of Low Back Pain Treatment Modalities on Lumbar Facet Loading

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Purpose—A majority of those who comprise the working population in the United States will suffer from low back pain and sciatica at some time in their lives. Many times, these symptoms are secondary to derangements of the lumbar intervertebral disc. A common accompaniment to disc disease is facet arthropathy.

Treatment options for lumbar disc disease include discectomy and chymopapain injection, which alter the load-bearing behavior of the disc. Clinical and experimental evidence indicates that an alteration in the mechanical behavior of the disc produces loss of alignment, abdominal movement, and loading of the facet joints. The resulting changes may lead to pro-

gressive degeneration of the facets, development of osteoarthritis, and back pain.

The objective of this study is to obtain data describing alterations in loadbearing characteristics of facet joints of lumbar spine segments following simulated treatment modalities for lumbar disc disease. During this study we will test cadaver spine specimens as a function of treatment modalities and physiological load types for various lordotic configurations of the lumbosacral spine. We will also measure facet joint loads using a pressure-sensitive film inserted between the articulating facet surfaces at L3-4, L4-5, and L5-S1 segments before and after discectomy or chymopapain injection at

L4-5 disc. With data, we will have a rational basis for designing clinical trials for physicians to use in choosing between two effective treatments, especially in cases of patients with pre-

existing pathology in facet joints. The data will also help to establish guidelines for prescribing post-treatment activities in such patients.

Myoelectrical Assessment of Human Lumbar Muscle Function

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Purpose—The purpose of this project is to develop and investigate objective quantitative measures of lumbar muscle function for patients with low back pain, and to provide research results and measurement techniques to enable easy use of these techniques in the clinic. Equipment and techniques have been developed in this laboratory for measurement and analysis of the frequency power spectra of myoelectric signals obtained during exercise.

Progress—Myoelectric data from the erector spinae muscles of a group of 40 normal subjects performing isometric extension exercises on a back-testing device have been collected to form a normal database. Thirty-six patients with low back injuries have been tested repeatedly during rehabilitation therapy using similar protocols. In addition, a single subject series of experiments have been performed to evaluate sources of variability in EMG spectral analysis fatigue rate measures. Finally, another set of normal data has been collected for trunk rotation exercises.

Several myoelectric frequency slope measures were shown to correlate with the isometric exercise load level. Significant improvement of the correlation between the fatigue measures and the load level has been obtained by expressing the load as a percent of body weight, as opposed to percent MVC, and by using the mean actual force output over the trial (as opposed to target force) to compute the percent body weight measure.

Preliminary Results—Using the preliminary

normal database, a strong correlation was observed between fatigue rate and load levels, when appropriately expressed. This curve, representing the first step toward defining normal erector spinal fatigue rates in isometric extension exercise, was used to compare the measured fatigue rates of a preliminary group of low back pain patients with expected normal values for the measured load level during exercise. These patients work at far lower load levels (approximately 20-30 percent body weight for 50 percent MVC) than normal patients, and exhibit somewhat higher than expected fatigue rates at these levels.

Experiments to explore the effects of perturbing isolated potential sources of variability of fatigue rate measure, while controlling others, were performed on a single healthy normal subject to eliminate intersubject variability. Variation in rest time between exercise trials and trial duration time were shown to significantly affect measured fatigue rates. Results indicate that all factors must be carefully controlled in group or single-subject applications in order to obtain meaningful results. In particular, trial duration can affect values for linear slope measures of spectral shift.

Myoelectric spectral analysis studies of normal subjects, performing isometric and isokinetic right and left torso rotation exercises on a prototype rotation unit, were carried out to determine which muscle groups participate in trunk rotation and to what extent. Published results based on EMG measures show that abdominal obliques were more consistent in providing torsional moment to the spine than were

the erector spinae.

Future Plans—Work is advancing in the development of a dedicated clinical instrument for performing power spectral analysis of myoelectric signals, and in the assembly of a solid normal database for low back pain patient data

to be collected and compared. Work also continues to refine basic measures of fatigue rate derived from frequency slope measures and load level in the complex musculature of the back to obtain an accurate absolute measure of fatigue characteristics.

Surgery for Severe Spinal Deformity and Back Pain

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Purpose—As part of a program which seeks to apply biomechanical analysis and new technologies to spinal surgery, two new techniques are being explored: simultaneous combined anterior and posterior fusion (SCAPF) and a modification to the Luque procedure.

SCAPF is advocated for severe, unremitting low back pain either as a primary or salvage procedure, particularly in cases with nerve root involvement. Based on biomechanical and anatomical studies, the procedure provides significant opening of narrowed lateral foramina, early weightbearing, and rapid fusion via internal fixation.

Progress—An interbody graft, of autologous or mixed autologous and bank bone, is inserted via the retroperitoneal, anterior route. This is

followed immediately by posterior distraction with Knodt or Harrington rods that anchor, bilaterally, onto the appropriate laminar superiorly and inferiorly onto the alar or a transverse pin located by the ilia. A conventional posteriolateral graft completes the procedure.

The Luque procedure, which employs prefashioned rods, has been modified by the utilization of self-locking nylon straps in place of the conventional malleable metal wires. As a result, the operating time can be halved, segmental loading is both uniform and predetermined, and the incidence of neurological complications is reduced. No breakages have been encountered during surgery or subsequent to surgery. Radio-opaque straps appear promising and have been manufactured on a limited basis.

Personality Characteristics and Their Effect on Post-Surgical Adjustment

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Purpose—The role of personality characteristics and psychological factors in relation to the low back pain syndrome has been of interest for many years. It is becoming increasingly evident that personality characteristics are predictive of a patient's adjustment and may have more of an influence than traditional variables such as duration of illness, disability status, and socioeconomic factors. The purpose of this pilot study was to investigate the relationship

between personality characteristics and post-surgical adjustment.

Progress—Subjects in this study were 15 post-surgical low back patients (6 males and 9 females) ranging in age from 27 to 66 (mean age 42.5). All subjects had the same surgeon. Six months postoperative subjects were given questionnaires to assess his or her personality (hardiness scale), self-assessment of condition (se-

semantic differential scale), coping (Lazarus' Ways of Coping Checklist), and adjustment.

The hardiness factor is a composite of three personality characteristics: commitment, control, and challenge. Persons scoring high on hardiness are committed to life rather than feeling alienated; believe they are in control of life events; and regard change to be a challenge rather than a threat. The semantic differential scale measures the patient's assessment of his or her condition by asking the patient to rate his or her feelings about the injury on a 7-point scale choosing between two polar adjectives. The Lazarus' Ways of Coping Checklist has the patient choose between problem-focused strategies and emotion-focused strategies. Adjustment was measured in four ways: subjective pain rating; downtime; activity impairment; and general psychological well-being (Bradburn Well-Being Scale). Demographic data were collected on all patients.

Preliminary Results—Results showed the expected relationship between certain demographic variables and adjustment measures. Income

was negatively related to pain rating and activity impairment was negatively correlated with time since onset and income. Hardiness was found to correlate negatively with activity impairment and positively with psychological well-being. Coping style had no effect on any measure of adjustment.

In all four areas of adjustment there was a consistent trend. Subjects high in hardiness with positive assessments showed the best post-operative adjustment, while those low in hardiness with negative assessment had the poorest adjustment.

The results of this pilot study indicate that personality measures of hardiness and self-assessment may be predictive of post-surgical adjustment. These tests have the advantage of being easy to administer and they take a short time to answer. This test battery may be an additional tool to aid in the rehabilitation of the low back pain problem patient about to undergo surgery. The preliminary results of this pilot project provide a model with which to conduct ongoing research.

Chronic Pain Mechanisms and Manifestations: Psychological Treatment for Chronic Back Pain

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Purpose—Chronic pain is a major source of human suffering and a major economic problem in American society. Because the problem has long gone unrecognized, there has been little research on which to base improvements in pain patient management.

We propose to carry out seven interrelated research projects involving varying disciplines that will shed light on the mechanisms of pain, the development of pain chronicity, the clinical manifestations of chronic pain, and the treatment of chronic pain. These consist of two studies to be done on the Clinical Pain Service, an additional study of chronic pain patients, and

four laboratory investigations. Two of the laboratory studies will employ animal physiology, the third is an animal pharmacology project, and the fourth will investigate chronic pain patients in a human subjects laboratory.

In order to accomplish this we will establish a multidisciplinary network of scientific interchange, collaboration, and resource sharing that is intended to enhance and expedite the work done under each of the individual projects. Interchange among project leaders will be both formal and informal, and will include monthly project seminars and semiannual consultation visits by outside scientists.

ND: YAG Laser Effect on Spinal Discs and Nerves

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Progress—The initial phase of the project was designed to determine the effectiveness of the ND:YAG laser in vaporizing intervertebral discs. This resulted in a disappointing amount of charring and heat buildup in the adjacent tissues, with documented pathologic changes noted.

An adaptation of the system utilizes a fiberoptic system with a synthetic sapphire tip to allow direct contact with the disc material. This adaptation allows much lower power utiliza-

tion, less heat production, and much less heat buildup in tissue. This system has been used in acute experiments with dogs and pigs.

The third phase of the experiment is beginning in which chronic animals will be studied. The fiberoptic contact point is introduced percutaneously under fluoroscopic control to vaporize the intervertebral disc. Follow-up studies will determine whether or not this system may be utilized for percutaneous vaporization of discs in humans.

A Comparative Analysis of Electrical Stimulation and Exercise to Improve Trunk Strength and Endurance in the Adult Female

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Purpose—The nonsurgical treatment of low back pain remains a controversial area. Advocates of both flexion and/or extension exercise programs have claimed success in the treatment of low back pain. It is, however, still unclear whether any low back pain exercise program can effectively improve trunk muscle strength and endurance. Electrical muscle stimulation is used in the rehabilitation of weak or injured muscles of the extremities, but its use in improving trunk muscle strength has not been reported.

A prospective study was designed to determine whether a low back exercise program or electrical stimulation treatments were equally effective in increasing normal isometric/isokinetic strength and endurance of the trunk muscles. It was also designed to determine whether exercises, or either of two different electrical stimulation parameters, were more effective in increasing the various strength parameters.

Progress—Subjects were 114 normal females between the ages of 18 and 48 (mean of 29 years) with an average weight of 57 kilograms

and an average height of 160 centimeters. None of the subjects had a recent history of low back pain and each was examined by an orthopaedic surgeon prior to participation in the study. Each subject's strength and endurance was determined by a standard test battery administered before and after treatment. The battery consisted of Cybex isometric and isokinetic evaluation of flexor and extensor trunk muscles, Natick standing pull tests, and Sorensen's endurance test. All testing was randomized except the Sorensen test, which was always performed last. Four randomized study groups were formed, consisting of two electrical stimulation groups (32 subjects in group 1 and 29 subjects in group 2), an exercise group (31 subjects), and a control group (22 subjects). Each group was comparable in terms of average age, weight, and height.

The exercise and electrical stimulation groups underwent treatment sessions lasting 30 minutes, 5 days-a-week for 4 weeks. The control group received neither exercise nor electrical stimulation treatments. Subjects receiving electrical stimulation treatments were prone with

two surface electrodes placed at the L2 to L4 levels bilaterally over the erector spinal muscles. A low voltage (45V), low frequency (35 Hz), muscle stimulator with a biphasic, symmetrical balanced rectangular pulse was used for group 1. A higher voltage (0-105 V), midrange frequency (300-500 Hz) muscle stimulator with a spike wave was used for group 2. The exercise group had a 5-minute warmup and cool-down period of stretching with 20 minutes of strengthening exercises.

Following the completion of post-treatment, data were subjected to an analysis of variance, and a T-test was used to establish significance. There was no significant improvement in isometric strength or in the Natick pull test in any of the groups compared to one another or to the control. A statistically significant ($p < .02$) increase was found in isokinetic strength in both the exercise group and the electrical stimulation group 1, compared to the control group. Electrical stimulation group 2 showed no significant increase in isokinetic strength parameters compared to the control group. There was no significant advantage, however, in strength improvement between the electrical stimulation and exercise groups. The electrical stimulation groups showed significant ($p < .02$ in group 1; $p < .05$ in group 2) increase in endurance compared to both the exercise and control groups. This was shown both by an increase in holding time as well as in total energy expended. Comparison of the two electrical stimulation groups indicated that the low-voltage, low-frequency

stimulation was more effective in improving isokinetic strength than the higher-voltage, mid-range, frequency stimulation.

Preliminary Results—The results of this study indicated that neither exercise nor electrical stimulation increased all parameters of strength. Neither electrical stimulation nor exercise appear to significantly improve isometric strength in a 4-week program. Stimulation and exercise are, however, both comparable in increasing isokinetic strength. In addition, electrical stimulation appears to be superior to exercise in improving endurance.

This study showed that electrical stimulation is applicable in the rehabilitation of the low back pain patient with decreased strength and endurance. It may be particularly useful in the patient with acute and subacute low back syndrome because of the passive nature of the stimulation as well as the concomitant TENS effect. However, it should be recognized that both exercise and electrical stimulation do not effect every measurable strength parameter in a similar way. Once recognized, selective training with electrical stimulation, exercise, or a combination of both are necessary for optimal results.

We are presently conducting a study using as subjects patients who are 4 to 6 weeks post-one-level disectomy. They are randomly placed in either a control group, an exercise group, or an electrical stimulation group.