

THE MEASURED EFFECTIVENESS OF ONE-SESSION
ELECTROMYOGRAPHIC BIOFEEDBACK ON PELVIC TILT PERFORMANCE
IN CHRONIC LOW BACK PAIN PATIENTS

by

CHARLENE DARYL GLASSER

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We accept this thesis as conforming
to the required standard




Martin L. Collis



Loren E. Acker



John J. Jackson



William H. Dyson

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UNIVERSITY OF VICTORIA

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Supervisor: Dr. Martin L. Collis

ABSTRACT


The effect of one-session electromyographic (EMG) biofeedback on pelvic tilt instruction to chronic low back pain patients was investigated. This study was conducted to determine the clinical usefulness of the Cyborg J33 electromyographic biofeedback machine. Thirty subjects were measured for pelvic tilt success and erector spinae electromyographic activity in one 30-minute session. The 15 subject experimental group received biofeedback in the second stage of the four stage experiment. Each stage, except stage four, consisted of establishing an erector spinae EMG baseline for one minute followed by five consecutive, five second pelvic tilt trials. Success was achieved when the subject reduced by one-half, in each pelvic tilt trial, the EMG baseline.

No significant difference was found between the experimental and control groups on the number of successful pelvic tilt trials or averaged EMG activity. A significant difference was found for the averaged EMG activity between females and males at the $p < .01$, and between those


subjects who performed at least one successful pelvic tilt and those who did not at $p < .05$.

The results suggest that the use of one session EMG biofeedback to help patients achieve pelvic tilt success may not be appropriate for muscle re-education or movement training. This study indicates not all chronic back pain patients may benefit from (EMG) biofeedback. The Cyborg J33 may prove useful as a screening tool in identifying patients most likely to learn different muscle or movement positions from biofeedback. In a group setting, the Cyborg J33 may be best utilized to provide additional visual and auditory cues in the demonstration of biomechanical principles applied to static and dynamic postures.


Examiners:




Martin L. Collis



John J. Jackson



Loren E. Acker



William H. Dyson

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DEDICATION

*This thesis is dedicated to Loren Acker,
who provided a spark of warmth and encourage-
ment in a cold winter.*

CHAPTER I

THE PROBLEM

Introduction

One of the basic elements in back care education is the pelvic tilt. The pelvic tilt refers to the normal or ideal angle of the pelvis in erect posture. Many back pain patients lack this normal pelvic tilt angle, due to an increased anterior curvature, or lordosis, of the lower back. Pelvic tilt maintenance, in both static and dynamic postures, reduces postural mechanical stresses, and provides vertebral column protection and stability. The reduction of postural mechanical stresses to control back pain is a common medical practice (Cailliet, 1979).

The pelvic tilt technique is presently taught by audio-visual presentation methods, such as slides, films, lectures and demonstrations, followed by patient practice sessions (Chadwick, 1980; Forssell, 1980; Kennedy, 1980; Mattmiller, 1980). Evaluation of pelvic tilt performance is most often acquired by instructor verbal feedback and patient self-knowledge of postural changes.

Greater patient participation and self-correction have been encouraged by biofeedback treatment of medical problems (Gottlieb, 1979; Malpe and Yue, 1978). Electromyographic biofeedback training has been used with chronic low back pain patients to reduce electrical activity of the low back muscles and promote relaxation in prone and seated positions (Calliet, 1979; Newman, 1978; Nouwen and Soligner, 1979). However, no studies have been conducted which use one session of biofeedback to help chronic back pain patients reduce electrical activity of the low back muscles during pelvic tilt performance in erect posture. The purpose of this study was to investigate whether one session of electromyographic biofeedback would be an appropriate and useful tool in pelvic tilt instruction to chronic low back pain patients.

The Problem

The purpose of this study was to investigate the effectiveness of one-session electromyographic biofeedback in erect posture pelvic tilt instruction to chronic low back pain patients.

Hypotheses

To fulfill the purposes of this study, the following hypotheses were tested:

(1) there will be a significant difference in measured pelvic tilt performance between non-biofeedback and biofeedback trials within and between experimental and control groups;

(2) there will be a significant difference between erect posture EMG measurements within and between experimental and control groups.

Delimitations

The delimitations of this study were:

(1) this study was confined to back pain patients referred by local physicians to a back education program in Victoria, British Columbia, Canada; and,

(2) the control and experimental subjects were chosen from those patients, who, after a physiotherapist's assessment, met the following criteria:

- (a) chronic low back pain of two months duration or longer;
- (b) no acute pain present;
- (c) no evidence of neurological deficits present, such as muscle wasting;

- (d) no previous back-related surgery;
- (e) no prescribed medicine intake;
- (f) no back treatment in progress; and
- (g) no palpable muscle spasm of the erector spinae muscles present.

Limitations

The study was limited by:

- (1) the reliability and validity of the Cyborg J33 electromyographic biofeedback machine;
- (2) the skill of the researcher in administering biofeedback training and pelvic tilt instructions;
- (3) the skill of the researcher in recording biofeedback readings;
- (4) the subjects' ability to follow instructions sufficiently well enough to complete the required tasks;
- (5) subject willingness to participate in a research study;
- (6) subject condition prior to pelvic tilt and biofeedback training; and,
- (7) the physiotherapist's ability to assess chronic low back pain patients according to the selection criteria outlined in the delimitations section.

Definitions of Terms

1. *Low Back.* For the purposes of this study, the low back was defined as the lumbosacral area of the back delineated by the lumbar and sacral vertebrae.
2. *Low Back Pain.* This term referred to a dull pain or ache in the low back area, which included sensations of tiredness, weakness and stiffness; the pain may vary in intensity and duration and may be connected with stresses to which the spine was subjected (Hult, 1954).
3. *Acute Low Back Pain.* This was defined as any sudden, intense pain of short duration in the low back.
4. *Chronic Low Back Pain.* This was defined as low back pain that had persisted for two or more months.
5. *Pelvic Tilt.* For the purposes of this study, the pelvic tilt referred to the action of placing the pelvis in the normal or ideal position. In this position, the anterior superior iliac spine and the top of the symphysis pubis were placed in the same vertical plane (Gray, 1966).
6. *Biofeedback.* This referred to the audio and/or visual responses of the Cyborg J33 electromyographic bio-feedback machine which represented transformations of erector spinae muscles electrical activity.
7. *Electromyography or EMG.* This was defined as the detection and recording of muscle-produced electrical

potentials. Electrical potential change is a result of ionic shifts of depolarization which create electrical discharges of 5-8 milliseconds duration, and whose total amplitude is measured in microvolts.

8. *Electromyographic Biofeedback*. This referred to the electrical activity of a muscle being transferred into continuous immediate visual and auditory information via a Cyborg J33 EMG biofeedback machine.

9. *Erect Posture Baseline*. This was defined as the EMG erector spinae activity level in erect or "easy standing" posture.

10. *Trial*. A trial was defined as a five second interval of time.

11. *Successful Trial*. In this study a successful trial occurred when a subject reduced, by half, erect posture baseline erector spinae electrical activity adjacent to the fourth lumbar vertebrae, as indicated by audio and visual feedback directed to the researcher only, or simultaneously to the researcher and the subject.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The literature on postural definitions uniformly incorporates the normal or ideal angle of the pelvis as an integral part of erect posture. Objective rather than subjective methods of postural and pelvic tilt evaluation are preferred, but the literature does not suggest any one best method of measurement. The literature relevant to electromyographic measured postural tonus is inconsistent. The relationship between electromyographic erector spinae muscle activity, fatigue, and low back pain has not been clearly established; however some researchers have demonstrated a relationship between erector spinae electrical activity and low back pain (De Vries, 1968; Grabel, 1973).

Behavioral medicine techniques have provided the opportunity for chronic low back pain patients to participate in their own recovery. Biofeedback has been used as a behavioral tool to teach relaxation in chronic low back pain treatment (Newman, 1978). Although biofeedback has been applied

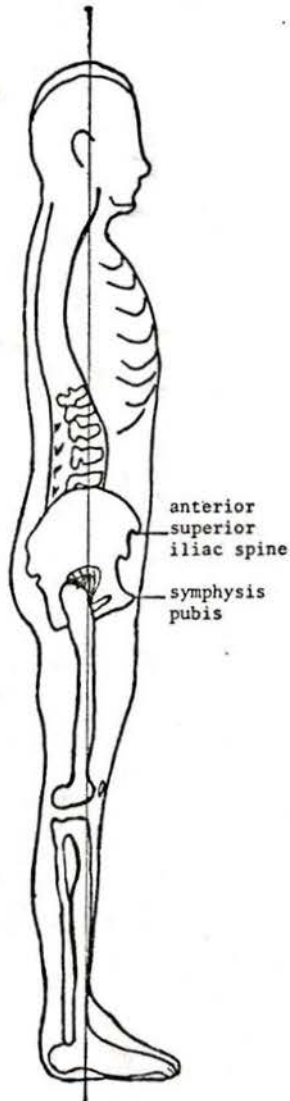
to erector spinae electrical activity reduction and pain control, it has not been extensively used to teach movement patterns, in particular, the pelvic tilt.

To cover the relevant literature as outlined above, this review has been subdivided into the following sections: posture and the pelvic tilt; posture and pelvic tilt measurements; electromyographic measurements of posture; electromyography, fatigue and low back pain; behavioral medicine; biofeedback; electromyographic feedback and chronic low back pain.

Posture and the Pelvic Tilt

Static posture is maintained by intrinsic mechanisms of the body counteracting gravity (Basmajian, 1978a). The muscular mechanism of posture maintenance is extremely economical. More muscular energy is required to bring the body back to the line of gravity, once thrown off, than is required to maintain erect posture (Basmajian, 1978a).

The idealized normal erect posture line of gravity points has been identified (Figure 1) and described by Basmajian (1978a); Cailliet (1968), and Kendall (1952). The Posture Committee of the American Academy of Orthopedic Surgeons in 1947, proposed a functional definition of posture (Cailliet, 1968). The Committee's understanding of posture included the concept of muscular efficiency in



Slightly posterior to the apex of the coronal suture

Through the external auditory meatus.
Through the dens or odontoid process of the axis.
Through the bodies of the cervical vertebrae.

Through the bodies of the lumbar vertebrae.

Through the sacral promontory

Slightly posterior to the center of the hip joint.

Slightly anterior to the center of the knee joint.

Slightly anterior to the lateral malleolus.

Through the calcaneo-cuboid joint.

Figure 1. Anatomical Structures Which Coincide With the Line of Gravity in Erect Posture (Note normal or ideal angle of the pelvis).

Source: Kendall, H., and others. *Posture and Pain*. New York: Robert E. Krieger, 1977, p. 10.

all postural attitudes (erect, lying, squatting and stooping).

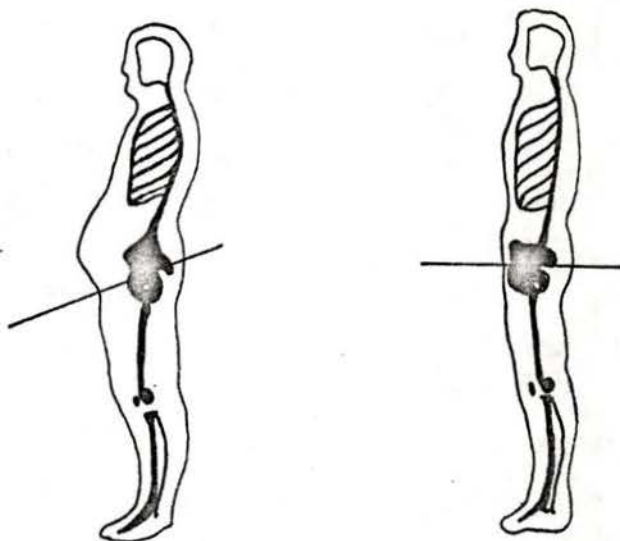
Structurally and functionally, the pelvic tilt is a part of posture (Gray, 1966). In idealized normal erect posture, the anterior superior iliac spines and the top of the symphysis pubis are in the same vertical plane (Figure 2). Another description of the pelvic tilt position includes the angle of the pelvic inlet and outlet plane from the horizontal plane. The pelvic inlet or superior aperture plane forms an angle from 50° to 60° from the horizontal plane from posterior to anterior. The pelvic outlet or inferior aperture plane forms an angle of approximately 15° from the horizontal plane.

The pelvic tilt position increases the separation of the lumbar vertebrae, and places the back in a neutral position which:

(1) brings the vertebral column into a position of greater stability and shock absorbing capacity by reducing the lumbar lordosis and flattening the lower back.

The intervertebral discs are under less pressure and can function to their full extent. Undue compression is reduced, along with the accelerated disc degeneration which often accompanies such pressure;

(2) reduces the angle and shearing forces between the lumbar vertebrae and between the lumbar and sacral vertebrae;



In strained position pelvis tilts forward, chin is out, and ribs are down, crowding internal organs, and lower back is arched (sway back).

In correct position chin is in, head up, back flattened, pelvis straight.

Figure 2. Posture Control - Posture is controlled mainly from the pelvis.

Source: *Back Talk*. Workers' Compensation Board of British Columbia, 1978, p. 12.

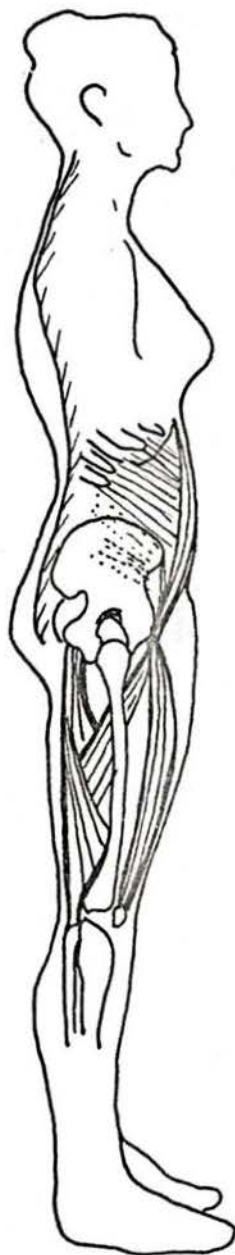
(3) increases the width of the neutral foramina, thereby preventing possible, or recurrent, nerve root pinch;

(4) reduces the weight bearing on the posterior units of the vertebrae, the facet joints;

(5) helps create a better balance between muscle and ligamentous support of the spine; and

(6) helps place abdominal musculature in the most efficient position to protect and stabilize the lumbar spine in both static and dynamic postures.

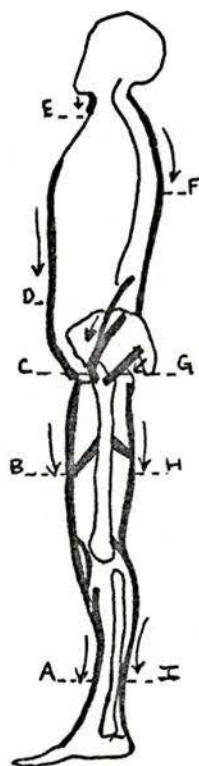
The muscles of the pelvis which determine pelvic alignment with the trunk and legs are illustrated in Figure 3. Four muscle groups; the abdominals, the hamstrings, the hip flexors, and the low back muscles control pelvic tilting. The abdominals pull upon the pelvis anteriorly, and the low back muscles pull up upon the pelvis posteriorly. The downward pull of the pelvis is controlled posteriorly by the hamstrings and is counterbalanced by the hip flexors' anterior downward pull and the upward pull of the low back muscles. Figure 4 illustrates the muscular control of posture which includes more muscle groups than used in pelvic control.



This figure shows the muscles attached to the pelvis which are chiefly responsible for the maintenance of good alignment of the pelvis in relation to the trunk and legs. The abdominals pull upward anteriorly and the hamstrings downward posteriorly to counterbalance the downward pull of the hip flexors anteriorly and the upward pull of the low back muscles posteriorly.

Figure 3. Muscles Responsible for Pelvic Movement

Source: Kendall, H. and others. *Posture and Pain*. New York: Robert E. Krieger, 1952, p. 58.



Antagonistic muscle groups responsible for erect posture. A, Tibialis anterior; B, Quadriceps femoris; C, Iliopsoas; D, Abdominals; E, Neck Flexors; F, Spinal Extensors; G, Gluteus maximus; H, Hamstrings; I, Triceps surae.

Figure 4. Antagonistic Muscle Groups Responsible for Erect Posture

Source: Rasch, P. and R. Burke. *Kinesiology and Applied Anatomy*. Philadelphia: Lea and Febiger, 1974, p. 452.

Posture and Pelvic Tilt Measurements

Postural research has been plagued by a lack of precise testing instruments, methods, and adequate posture standards. These inadequacies have been noted in extensive reviews of postural appraisal literature by Clarke (1976, 1979) and Mathews (1978). Fullilove (1969) cited the limitations of objective and subjective type tests as having contributed to the "chaotic" conditions of postural research results.

The measurements on one part of posture, the pelvic tilt position, have been difficult to quantify and thus have limited applicability to research. Gardiner (1966) suggested the use of the pelvic inclinometer to measure pelvic tilt angle. At best, the region of 30° is given as the normal angle between the symphysis pubis and the posterior superior iliac spine.

Tichaeur (1973) developed the lordosimeter to quantify measurement of postural deviations during materials handling. The lordosimeter has not yet been adapted for practical application. Troup and Chapman (1969) calculated lumbar movement indirectly. They first measured the range of movement at the hip joints and subtracted from it the estimate of the range of movement between the thoracolumbar region and the femora.

The measurement of posture, or any one part, has been a difficult task. The literature does not suggest any one method as best. Researchers have used traditional medical measurement tools. To date, the goniometer is still in use as the most practical method of measuring joint mobility (Jones and Wolf, 1980). The electromyographic research on postural measurements has produced quantifiable data on muscular activity in static and dynamic postures. Data of this nature may provide the basis for evaluation of pelvic tilt performance.

Electromyographic Measurements of Posture

Jacobson (1938, 1943) developed and refined electromyographic equipment to measure the electrical changes which occur in muscles as a result of relaxation. Basmajian (1978a) and Joseph (1960) have contributed, with Jacobson (1938, 1943), to the development and review of electromyographic research.

Basmajian's (1978a) work on various muscle groups, individual muscles, parts of individual muscles, and individual motor units demonstrated the precise control a person can exercise over her/his muscular system. Basmajian's (1978a) work led him to propose a definition for muscle tone. Tonus can be exhibited by a muscle in a resting state concurrent with electrical silence over

short periods of time in a well relaxed subject. This is possible because Basmajian (1978a:79) states

. . . the general tone of a muscle is determined both by the passive elasticity or turgor of muscular (and fibrous) tissues and by the active (though not continuous) contraction of muscle in response to the reaction of the nervous system to stimuli.

The literature on postural tonus exhibits inconsistent results. Kelton and Wright (1949) and Ralston and Libet (1953) found no electrical activity in the erector spinae muscles during "easy standing." De Vries (1965) also measured electrical activity of the erector spinae muscles in "easy standing." Unlike previous researchers, he found a significantly higher activity level, $p < .02$, when compared to the rest position. De Vries (1965) attributed the failure of previous researchers to record any erector spinae electrical activity to researchers' (1) equipment of insufficient sensitivity; (2) inadequate sampling methods; and (3) non-correction of electrical activity created by thermal and amplifier noise. Basmajian's (1978a) review of the literature revealed most researchers reported a "low level of discharge" in the erector spinae muscles in erect posture. From this, Basmajian concluded that the fatigue of standing is not due to muscular fatigue, but possibly of ligamentous origin.

Electromyography, Fatigue and Low Back Pain

Several researchers (Brown, 1972; De Vries, 1968; Jayasinghe, 1978; Kraus and Raab, 1961) have observed that muscle weakness, or fatigue, is associated with low back pain. Fatigue has been a nebulous term as defined by Basmajian (1978a), who considered it a complex phenomenon or a complex of numerous phenomena.

Brown (1972) concluded, after surveying fifty years of industrial-related lifting literature, that muscle fatigue or weakness was a major contributing factor to low back pain. Kraus and Raab (1961) attributed 80 per cent of low back pain to postural muscle deficiencies, such as lack of flexibility and general muscle weakness. Alston (1966) found the maintenance of low back pain may be due to hamstring tightness and trunk muscle weakness, even though there may be a normal relationship between the trunk flexor and extensor groups.

Basmajian (1978a) found no agreement in the literature regarding the relationship between muscle fatigue and muscle electrical activity. Edwards and Lippold (1956) found an increase in electrical discharge when isometric contractions were sustained. Eason (1960) suggested a muscle must, at the onset of fatigue, progressively recruit additional motor units to maintain the same level

of tension over time. He felt this would explain the progressive increase over time of the amplitude of integrative electromyographic results he obtained.

With reference to the erector spinae muscles (Chapman and Troup, 1970, 1972) found inconsistencies in electrical activity at the onset of fatigue. De Vries (1968:180) observed, in his own words, "a clear cut difference in EMG fatigue curves" between those who did and did not, upon 22 minutes standing, develop pain in the extensor muscles of the lumbar area. Those who developed pain upon standing had higher EMG fatigue curves than those who did not. De Vries (1968) felt these differences in EMG fatigue curves could be explained by his "spasm theory of muscle pain" for those people whose pain was not associated with any structural anomaly or traumatic incident. De Vries' (1968) work also demonstrated the effectiveness of static stretching, which reduced to one-half baseline, the increased erector spinae electrical activity created after 22 minutes standing.

Jayasinghe (1978), after modifying De Vries' (1968) research in several ways, also reached the same conclusion: muscle weakness or fatigue is associated with low back pain. Jayasinghe used recent back pain patients, instructing them to stand for only six instead of 22 minutes. The EMG activity level of control subjects in Jayasinghe's study

decreased over time, compared to the low back pain subjects, whose mean square value of EMG level increased over time of erect standing.

Grabel (1973) found low back pain patients had higher EMG levels than did normal subjects. Grabel suggested a relationship existed between elevated EMG measured back muscle tension and chronic low back pain. Those with lumbar muscle spasm have been found by Basmajian (1978b) to demonstrate reduced EMG levels in the low back. Thus, the source of pain may influence the level of EMG activity.

If, as Basmajian (1978a) concluded, easy standing requires little or no muscular activity in the low back, chronic low back pain patients may have higher EMG levels due to improper posture contributing to muscular imbalance, tension and pain. Therefore, any attempt to correct posture by pelvic tilt instruction may help restore proper posture, reduce low back electrical activity and pain.

Plummer (1980) has listed the main treatment modalities used to correct posture: antigravity exercises, muscle stretching, sensory awareness, massage, rolfing, and spinal manipulation. A potentially useful tool recently incorporated into treatment programs has been behavior modification. Applied to medical problems, behavior

modification has provided researchers and medical practitioners the opportunity to use non-invasive tools and obtain quantifiable results upon which clinical outcomes can be based.

Behavioral Medicine

Behavioral medicine has been defined by Pomerleau (1979:656) to be:

(a) The clinical use of techniques derived from experimental analysis of behavior therapy and behavior modification for evaluation, prevention, management or treatment of physical disease or physiological dysfunction; and (b) the conduct of research contributing to the functional analysis and understanding of behavior associated with medical disorders and problems in health care.

Incorrect posture is commonly recognized by the medical profession as detrimental to health and contributing to pain (Cailliet, 1979). A change in postural behavior can be accomplished in the many ways as suggested in the last section by Plummer (1980). Back education programs described by Bush (1980) and Imrie (1979) include pelvic tilt instruction similar to the clear and simple instruction of Fahrni (1976) and the Schering Corporation (1972), (Appendix F). Such instruction is most often presented in written, verbal and graphic form with the use of mirrors, floors, walls and verbal cues providing performance feedback.

The verbal, visual and proprioceptive information provide initial feedback, a part of every therapy program, but such information is not specific, continuous or always sustained when the pelvic tilt is required in different postural positions or movements. Quantification of performance is also lacking from these traditional teaching methods.

Behavioral medicine is based, in part, on the principles of operant conditioning as promulgated and popularized by B.F. Skinner (1953). The main principle of operant conditioning is that a behavior is increased or decreased by its consequences. It is a type of treatment which has allowed chronic back pain patients to participate actively in self-reduction and control of pain behaviors through quantifiable measures.

A relevant example of behavioral medicine, as it has been applied to postural problems, can be found in the work of Azrin and others (1968). They applied operant conditioning techniques to the medical problem of slouching. Twenty-five adults wore a portable operant apparatus during their normal working day. When a subject slouched, a warning stimulus was followed by an "aversive" tone for the duration of the slouching. According to Azrin (1968:99), "slouching was thereby punished by the onset of the tone, and non-slouching was reinforced by tone termination and postponement." Azrin concluded that simple

response feedback was not responsible for postural changes after demonstrating that slouching decreased for each subject, when slouching produced an aversive tone, and increased for subjects, when slouching terminated the tone.

Azrin called his research a form of behavioral engineering fulfilling six requirements: (1) behavioral definition; (2) apparatus definition; (3) response precision; (4) effective stimulus consequence; (5) programming the stimulus consequence; and (6) portable device. Azrin, using the above requirements, modified biofeedback to serve a form of operant conditioning. He defined the problem in behavioral terms, and selected an apparatus that could physically sense an essential aspect of that behavior. The response precision was based on apparatus output designed to be activated only by identifiable specific behavior and no other behavior. The effective stimulus consequence involved discovering some stimulus event able to be delivered physically, that was reinforcing, in the case of desired behavior, or aversive, in the case of undesired behaviors. Programming the stimulus consequence involved programming the stimulus as a consequence of the response. Finally, Azrin used a portable device that identified the response and delivered the stimulus to a subject during a normal day's activities.

Behavioral engineering, as outlined above, represents a direct modification of biofeedback techniques for operant conditioning purposes. The relationship between operant conditioning and biofeedback is not a precise one and therefore a discussion in the next section is presented.

Biofeedback

Biofeedback or external psychophysiological feedback is considered by Mayr (1970) to be a special instance of feedback. Biofeedback in any form is a way of providing a person with information about what is going on inside her/his body that is normally not available. This information allows a person the opportunity to voluntarily control the process about which this information is provided (Gaarder and Montgomery, 1977).

The theoretical and abstract concepts of biofeedback have been explained historically by Gaarder and Montgomery (1977). The historical basis and principles behind the clinical application of biofeedback have been concisely summarized by Basmajian (1979). Wolf (1979) and Green and Green (1979) have outlined differing models for the anatomical and physiological basis for biofeedback.

Gaarder and Montgomery (1977) have reduced the biofeedback system to the following elements: transducer, amplifier, signal reducer and signal display. In this

system the subject completes the feedback loop (Figure 5). The transducer is usually in the form of laboratory equipment which receives signals from a subject and converts them into a measurable form which is then amplified to an electrically manageable quantity. The quantity is next filtered out through the signal reducer to produce useable information which the signal display converts to some sensation or stimulus as a light or sound.

The electronics of biofeedback systems have been simplified for clinicians by Cohen (1979). Fowler (1974) and Stoyva (1979) have identified common operating errors and patient needs in the clinical setting. Equipment needs in the rehabilitation setting have been examined by Fernando (1979). Biofeedback strategies in the physical clinical setting have also been reviewed (Gaarder and Montgomery, 1977; Fowler, 1974; and Baker and Wolf, 1979).

Wolf (1979) warns against confusing operant conditioning with electromyographic or EMG biofeedback training techniques. According to Wolf, electromyographic biofeedback allows a subject to receive continuous, neutral information about the level of muscular activity. Control over muscle potential or muscle electrical activity is considered to be its own reward. The immediate knowledge of success provided by sensory feedback enhances the subject's learned control over the response, whether or not

TYPICAL BIOFEEDBACK SYSTEM COMPONENTS

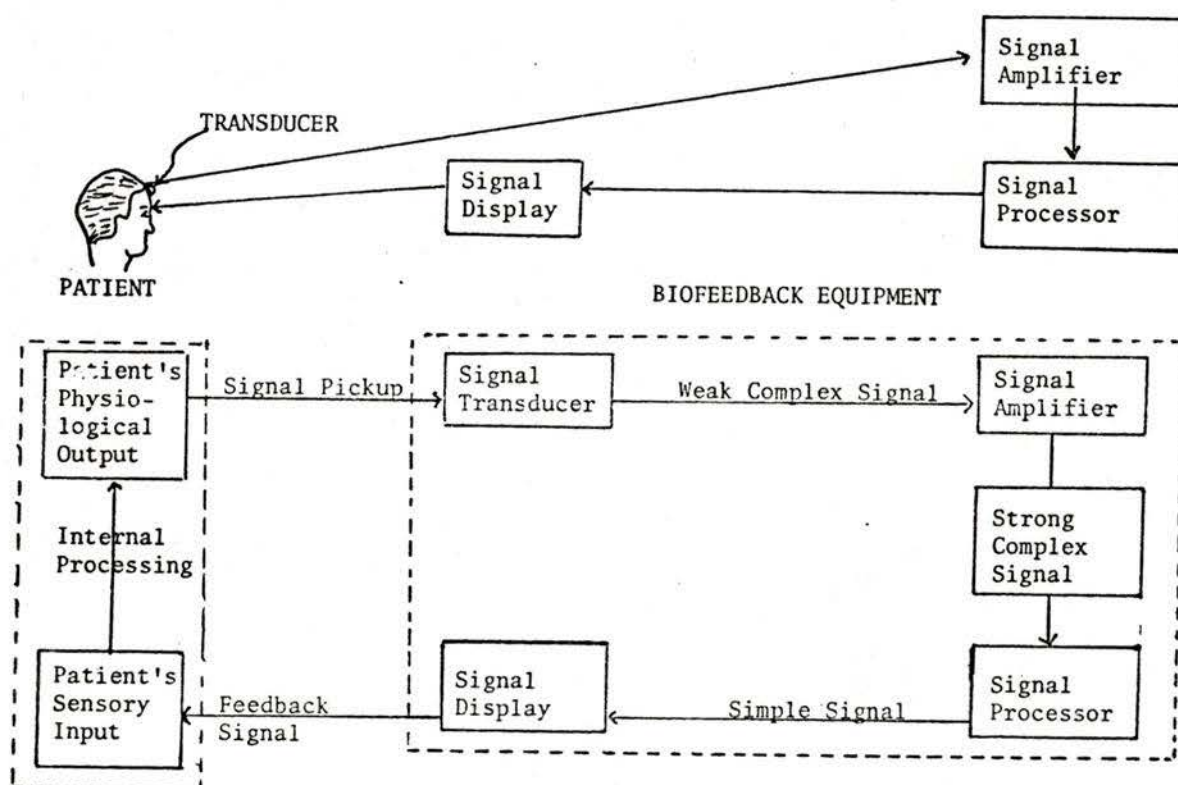


Figure 5. Elements of a Biofeedback System.

Source: Gaarder, K. and P. Montgomery, *Clinical Biofeedback: A Procedural Manual*. Baltimore: The Williams and Wilkins Co., 1977.

a subject understands what physiologic response she/he is controlling. Birk (1973) has listed muscle electrical activity as one of several variables modifiable by biofeedback.

Operant conditioning, as demonstrated in Azrin's (1968) research, did not provide the precise and continuous signal proportional to a subject's response as does EMG biofeedback training. Instead, a particular behavior was selected (slouching) and selectively reinforced (non-slouching by no aversive tone) so that the non-slouching behavior could be increased in frequency. Gaarder and Montgomery (1977) mentioned another dissimilarity between operant conditioning and biofeedback training, the nature of the feedback. According to them, the biofeedback signal is neutral and is distinct from the motivating value given to a subject by the compelling reward or punishment used in operant conditioning. Gaarder and Montgomery (1977) express the hope that important advances in the use of feedback might be expected when feedback information can be delivered in a manner not demeaning to the subject, yet distinct from conditioning experiment motivational methods.

There are many limitations to the proposed differences between biofeedback and operant conditioning. One assumption being made is that biofeedback information is neutral and continuous, and is therefore not in the same class as operant

conditioning. An argument can be made for the non-neutral quality of the biofeedback signal, the discrete nature of the continuous signal, and the question of what serves as a reinforcer. The nature of success is also arbitrary, because a subject has to learn what is considered successful. It is perhaps too simplistic to distinguish biofeedback and operant conditioning on the length and nature of the signal alone, for such a view confines the scope of operant conditioning and therefore limits biofeedback usefulness.

The next phase of biofeedback research should, according to Gaarder and Montgomery (1977:5) include:

The evolution of criteria for evaluating the clinical use of a technique and the emergence of control theory principles as a framework for understanding what happens in biofeedback learning.

Schwartz (1979) has called for a research oriented perspective in the clinical use of biofeedback to promote successful clinical outcomes. Green and Green (1979) view biofeedback as a useful tool in preventive medicine. Baker and Wolf (1979) have reported on biofeedback's applicability to therapeutic exercise as a useful adjunct to traditional therapy.

Malpe and Yue (1978) have summarized the advantages of electromyographic biofeedback to neuromuscular rehabilitation. They found it to be an inexpensive, simple, innocuous, and non-invasive method of therapy, that the majority of

patients can quickly and easily learn. The patient's motivation is improved because she/he must take an active role in her/his own therapy. In certain cases, the total treatment time is reduced by almost half. Malpe and Yue concluded that biofeedback makes the therapy session enjoyable and interesting for both the patient and the therapist. A recent study by Middaugh and Miller (1980) confirmed the above and provided another step in the direction of establishing a scientific basis for the use of EMG biofeedback in muscle re-education.

An example of quick and easy learning is found in the study by Jacobs and Felton (1969). They demonstrated that EMG biofeedback had an effect after one session on subject controlled relaxation of local muscle spasm. "Both normal and neck-injured subjects were better able to relax activity of the trapezius muscle during a single trial with EMG feedback than during a single trial that was identical except for the absence of EMG feedback" (Jacobs and Felton, 1969:34).

The above biofeedback advantages are in agreement with Nachemson's (1979) suggestions for clinical treatment of low back pain. Nachemson recommends inexpensive, simple, non-invasive treatment of chronic low back pain patients when the source of pain is unknown. Biofeedback may prove a useful adjunct to traditional therapy techniques of patient

self-knowledge leading to self-correction from the muscular system. How EMG biofeedback training and operant conditioning techniques may be best utilized either individually or together is still in the process of being resolved, especially for chronic low back pain sufferers.

Electromyographic Biofeedback and Chronic Low Back Pain

Chronic back pain patients at the Casa Colina Hospital for Rehabilitation Medicine in California received electromyographic biofeedback training as part of their treatment program (Gottlieb, 1979). EMG biofeedback was one part of an alternative, non-invasive program approach to chronic pain which recognized cognitive and emotional factors while stressing patient self-regulation of pain.

Gottlieb (1979:998) listed the ways in which EMG biofeedback training at the Casa Colina Hospital was used:

1. To eliminate the patients' belief in the classic mind-body dichotomy. Biofeedback experiences can provide the patient with experimental links among ideation, thought, images, increases or decreases in physiological arousal, and increases or decreases in pain experience.
2. To teach the patient how to manage upper and lower-body physiological indicators of pain.
3. To teach the patient how important he is in his own recovery.
4. To implement a method of attaining patient self-responsibility.

5. To teach the patient skills for pain reduction that he can use at home and work.

Both Cailliet (1979) and Newman (1978) have reported the use of EMG biofeedback to assist in relaxation training of chronic back pain patients. Newman (1978) used EMG biofeedback as part of a multidisciplinary approach to a treatment which emphasized patient control over voluntary musculature, certain autonomic responses, and the effect of tension on pain. Cailliet (1979) recommended and used EMG biofeedback training to interrupt the pain process and pain related behaviors in chronic pain sufferers.

Nouwen and Solinger (1979) used EMG biofeedback training of the erector spinae muscles to determine its effect on EMG level control, and pain in chronic low back pain patients. They also examined the relationship between EMG levels and reports of pain during training and at follow-up. No relationship was found between EMG level and pain.

The results of Nouwen and Solinger (1979) were in disagreement with the previous study of Budzynski (1973) and in agreement with Phillips (1977). In tension headache patients, Phillips found that pain complaints continued to decrease following biofeedback treatment, while muscle tension did not. Nouwen and Solinger (1979) were able to reduce erector spinae electrical activity and level of pain during training. At follow-up, however, the EMG level rose

to its initial level indicating a lack of self control on the part of the back pain patients. The level of pain at follow-up continued to decrease for those patients who had made a substantial decrease during training. For those patients who made no substantial decrease during training, pain reduction at follow-up remained unchanged from the post session level.

In a study by Kravitz (1978), differential relaxation training was conducted with and without patients receiving paralumbar muscle activity feedback. Initial pilot work had failed to reduce the patient's pain and EMG activity level after "resting state" relaxation. Both differential relaxation groups, with and without feedback, achieved significant reductions in EMG activity during tension exercises at posttraining. Sixty-nine per cent of all patients tested reported a decrease in back discomfort. No follow-up study was performed to determine if reductions in EMG activity and pain were maintained, increased or reduced further.

Only one study was found which used EMG biofeedback to help re-educate postural muscles. Jones and Wolf (1980) used EMG biofeedback to retrain the back muscles of one chronic low back pain patient who had not responded to two years of traditional therapy. The back muscles were retrained during trunk and lower extremity movements in 15 sessions over a five week interval. A mini-trainer

was used to reinforce biofeedback training in the occupational setting. At the end of the training period, low back pain and EMG activity were reduced; hip and spinal motion were increased. One of the positions studied by Jones and Wolf was the posterior pelvic tilt in easy standing. Their subject was able to minimize the variability in EMG activity of the low back musculature over the 15 sessions. Similar reductions were obtained for knee bending, stooping, head positional changes, and anterior movements of the trunk in relation to the pelvis.

Summary

The pelvic tilt as an integral part of proper posture and body mechanics has been consistently emphasized in prevention and rehabilitation programs (Bush, 1980; Imrie, 1979; Nachemson, 1979; Rowe, 1969; Snook, 1972; Troup, 1979). Until recently, patient involvement in back care has been minimal. The use of audio-visual presentations and demonstrations have predominated as the main sources of information, followed by patient practice.

The behavioral approach to pain management has broadened the range of treatment modalities available. It has also encouraged the patient to assume more responsibility for her/his back pain. EMG biofeedback has been used successfully in multi-disciplinary chronic pain clinics to assist

patient self control of muscle tension and perceived pain. The literature supports the logical extension of EMG biofeedback training from muscle tension control to learning the proper postural muscle movements such as those required in pelvic tilt performance. The pelvic tilt requires more than an ability to relax local musculature; it is a complex behavior which EMG biofeedback training may be instrumental in teaching.

The literature indicates electromyographic biofeedback may prove to be a valuable, non-invasive, economic and effective treatment tool in patient self-control of posture through pelvic tilt instruction. It is the purpose of this study to demonstrate the usefulness of one-session EMG biofeedback in pelvic tilt instruction.

CHAPTER III

METHODOLOGY

Introduction

The researcher investigated the effectiveness of one-session electromyographic biofeedback on pelvic tilt instruction to chronic low back pain patients. The literature reviewed in Chapter II supports the concept of erector spinae muscle electrical silence as an indicator of ideal or normal pelvic tilt angle in erect posture. Electromyographic biofeedback was used to provide the subject with information about her/his progress toward electrical silence, while performing the pelvic tilt.

Design

Thirty subjects with chronic low back pain, were randomly assigned to either an experimental or control group to participate in a one half-hour pelvic tilt learning and practice session (Table 1). To match subjects by age and sex per group, the control group received the first subject of any particular age, sex combination. When another patient matched a control subject by age and sex, she/he was

assigned to the experimental group. In Stage II, the experimental group only, received EMG biofeedback during pelvic tilt trials. Both groups, however, received verbal feedback from the researcher during treatment of pelvic tilt trials in Stages I, II and III.

Erect posture erector spinae EMG readings constituted baseline measurements and were taken according to Cyborg J33 instructions (Appendices A,B). EMG baseline measurements were taken prior to pelvic tilt trials in Stages I, II and III. They were the only measurements taken in Stage IV. Table 1, page 37, summarizes the above research design. Appendix C contains the subject data sheet.

Sample Selection

The subjects in this study were volunteers from the back pain patients referred by local physicians to participate in a hospital back education course. Patients waiting to take the course who met the following criteria, upon a physiotherapist's assessment (Appendix D), were asked to volunteer (Appendix E).

The criteria listed below reflect conditions the majority of low back pain patients experience. To avoid patient discomfort, no patient was asked to volunteer who had acute pain or muscle spasm. These two factors along with neurological deficits and back-related surgery have been

TABLE I: RESEARCH DESIGN

	Control n = 15	Experimental n = 15
STAGE I	Erect Posture Baseline Pelvic tilt trials with no biofeedback	Erect Posture Baseline Pelvic tilt trials with no biofeedback
STAGE II	Erect Posture Baseline Pelvic tilt trials with no biofeedback	Erect Posture Baseline Pelvic tilt trials with biofeedback
STAGE III	Erect Posture Baseline Pelvic tilt trials no biofeedback	Erect Posture Baseline Pelvic tilt trials with no biofeedback
STAGE IV	Erect Posture Baseline	Erect Posture Baseline

Erect posture baseline measurements: one minute at ten second intervals.

EMG of erector spinae muscles.

Pelvic tilt measurements: five, five-second trials per stage.

Number of successful pelvic tilt trials.

Treatment: Biofeedback in Stage II for the experimental subjects.

found to influence EMG activity (Basmajian, 1978b; Jones and Wolf, 1980; Wolf, 1979). The pilot study confirmed the above conditions for best use of biofeedback. Chronic pain may have behavioral components (Fordyce, 1968, 1973) and therefore be subject to modification. To assure some measure of control, only those patients not receiving treatment were asked to volunteer, if they had:

1. chronic low back pain of two or more months duration;
2. no acute pain present;
3. no neurological deficits such as muscle wasting;
4. no previous back-related surgery;
5. no intake of prescribed medication;
6. no other treatment in progress; and
7. no palpable evidence of erector spinae muscle spasm.

Experimental Exercise

A standardized explanation and demonstration of the pelvic tilt (Fahrni, 1976) was given to each subject (Appendix F). Five, five-second pelvic tilt trials were performed by the subject in each of the three stages. The researcher signalled verbally the beginning and end of each trial.

A successful trial was recorded when the subject, while pelvic tilting, reduced by one-half, the erect posture baseline electrical activity of the erector spinae muscles. Fowler (1974) suggested such a reduction could be expected within one session. Cyborg J33 instructions for machine baseline reduction settings are described in Appendix G.

Experimental Treatment

In Stage II the experimental group received audio and visual feedback from the Cyborg J33 biofeedback machine during the five pelvic tilt trials.

The subject's ability to control audio and visual feedback through pelvic tilting determined the number of successful trials. A successful trial was one in which the subject was able to reduce the frequency of clicking sounds to zero and simultaneously move the meter needle to the left of centerline. These changes represented the subjects' ability to reduce by one-half baseline, the erector spinae electrical activity in erect posture.

Instrumentation

The Cyborg J33 portable electromyographic biofeedback training unit was used in this study (Figure 6). The feedback, representing changes in integrated muscle tension, was both audio and visual. The audio feedback was in the

form of a continuous series of clicks, whose frequency varied in proportion to EMG activity. The Cyborg J33 analogue meter with its fluctuating needle provided the visual feedback.

The machine, Cyborg J33, was used according to instructions (Appendices B and G) to take erector spinae baseline measurements and to provide feedback on erector spinae muscle activity. The electrode connection and resistance were checked in accordance with the Cyborg J33 manual instructions. Use of a dummy subject, an insulated sensor strip, indicated noise was low and uniform in the treatment room (Basmajian, 1979).

Procedures

Each subject was given a brief explanation of the study and of the Cyborg J33 biofeedback machine. The explanation to the control group did not include any reference to the subject receiving machine biofeedback. Visual feedback was eliminated by turning the machine toward the researcher and away from the subject. All subjects received verbal feedback from the researcher during all pelvic tilt trials.

Skin preparation for electrode or sensor placement conformed to Cyborg instruction manual specifications (Appendix H). Electrodes were placed on and adjacent to

the fourth lumbar vertebrae using anatomical reference points (Fowler, 1974). It must be acknowledged that other muscle groups may influence EMG activity from the chosen site. Jones and Wolf (1980) observed from cadaver investigation that the transversospinalis muscles might contribute to surface electrical activity measured at the lumbar four area. A disposable strip of three electrodes manufactured by the Cyborg J33 distributor was used to standardize electrode placement (Figure 6). To reduce the risk of electrode displacement, the skin tension was maximized during electrode application by placing the subject in the pelvic tilt position while standing.

After electrode placement the subject was instructed to assume an "easy standing" erect posture. Baseline erector spinae electrical activity was recorded at ten second intervals for one minute. These measurements were repeated in Stages II and III. In Stage IV this was the only measurement taken (Appendix C).

Pelvic tilt instructions from Fahrni (1976) (Appendix F) were explained and demonstrated. Each subject was requested to perform five consecutive five-second pelvic tilt trials during Stages I, II, and III.

Data Collection

All data were collected during June, July and August of 1980. Data on erector spinae electrical activity, measured in microvolts, were read from the Cyborg J33 biofeedback machine meter, range and shaping controls. Audio and visual (meter) feedback from the same machine provided data on the number of successful trials. All data collection was conducted in a separate treatment room, kept uniform in appearance and isolated from electrical equipment.

Data Analysis

Due to a lack of homogeneity of covariance, the CLYDE MANOVA computer program was used to run a multivariate analysis of variance test to determine if the following data groups came from different populations in items 1 and 2:

1. the number of successful pelvic tilt trials between and within the experimental and control groups, in total and by stage;
2. the electromyographic data, in total and by stage, between and within the experimental and control groups.

Analysis of variance was used to distinguish any significant difference between the populations in items 3 through 5:

3. the electromyographic data from all stages within and between the successful (those who could perform at least one pelvic tilt successfully) and the unsuccessful group (those who could not perform at least one pelvic tilt successfully);
4. the electromyographic data from all stages within and between the experimental successful subjects and the control successful subjects; and
5. the electromyographic data from all stages within and between the female and male subjects.

The analysis of variance is a robust parametric test (Edwards, 1967). For this reason the data were subjected to it even though the assumption of normal distribution and equal population variances were not strictly met. The sample size of 30 is too small to determine if the data came from a normal population, and thus one cannot rule out this possibility.

The SPSS computer program was used to determine the correlation between pain duration and the variables of age, height, weight and number of successful pelvic tilts. The correlation between age and the number of successful

pelvic tilts was also calculated by the same program.

A multiple regression analysis was performed using the SPSS package to determine which predictor variables; age, weight, height, occupation, sex, and pain duration, accounted for the most variance in pelvic tilt success.

*CHAPTER IV**RESULTS*

The purpose of this chapter is to present research findings relevant to the hypotheses stated on page three. The following chapter will deal with interpretation, implications and recommendations based on these research findings.

One session with five trials of EMG biofeedback did not influence pelvic tilt performance. No significant difference was found in pelvic tilt success between those in the experimental group who received biofeedback in Stage II, and those in the control group who did not (Appendix O). Nor did biofeedback, in Stage II, significantly influence pelvic tilt performance in Stage III. Only 12 of the 30 subjects could even perform at least one successful pelvic tilt. Of these, five were from the 15 experimental group subjects and seven were from the 15 control group subjects. The graph on page 48 demonstrates for each successful subject the number of pelvic tilts per stage. While not statistically significant, there appears to be a tendency for those receiving biofeedback to maintain or increase the level of pelvic tilt success. Subjects in the control group demonstrated pelvic tilt performance

that were sporadic or decreasing over the three stages (Figure 7).

A higher but not statistically significant percentage of men, 45 per cent, or five out of 11, performed successful pelvic tilts compared to the women's 37 per cent, or seven out of 19. Of the five men who achieved pelvic tilt success, four were from the control group. Four of the seven women subjects who performed successful pelvic tilts were from the experimental group.

The five electromyographic recordings in each stage for each person were averaged. No significant difference in EMG was found between groups or between stages (Appendices P, N). By sex, males had a significantly higher EMG reading at $p < .01$ than the female subjects (Figure 8, Appendices Q, N). This difference, by sex, was not significant when the EMG of successful pelvic tilt males and females was compared. However, the EMG of the successful group versus the unsuccessful group was significantly different at $p < .05$ (Figure 9, Appendices Q, N). When the successful group was divided into control and experimental groups, no significant difference was found between EMG results.

Personal data was collected for each subject and is summarized in Appendix K. The raw data per subject by

Figure 7

Pelvic Tilt Performance

Experimental

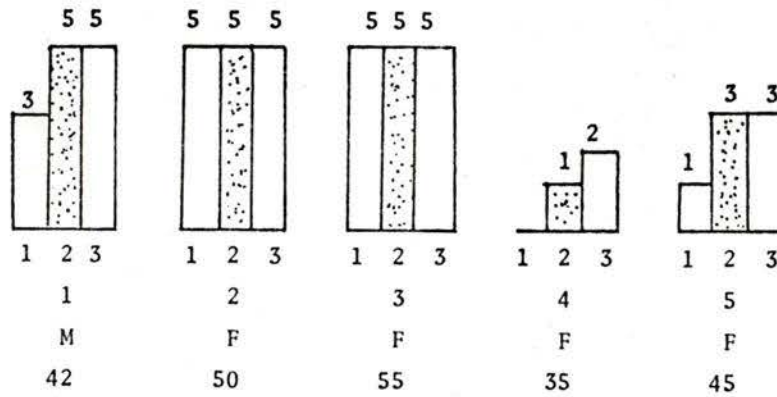
Number of Successful Pelvic Tilts

Per Stage

Per Subject

By Sex

By Age



Biofeedback

No Biofeedback

F Female

M Male

Control

Number of Successful Pelvic Tilts

Per Stage

Per Subject

By Sex

By Age

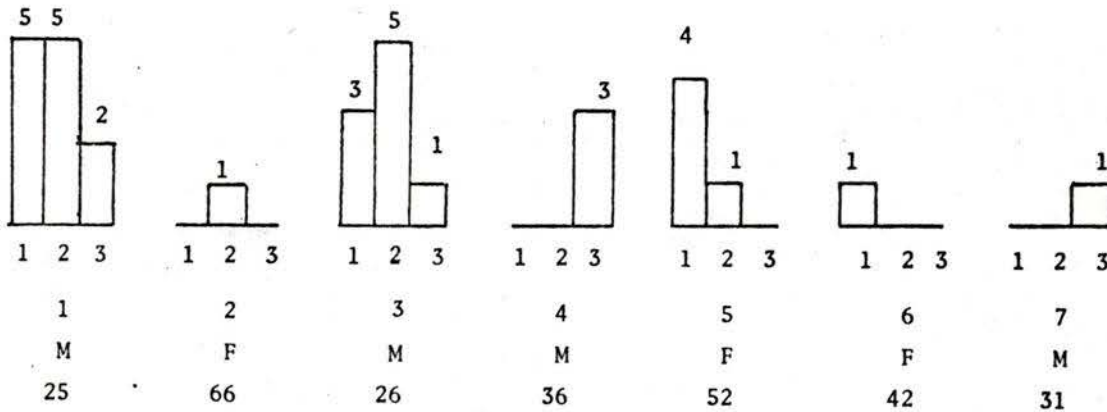


Figure 8
Averaged EMG Per Stage By Sex

Female versus Male

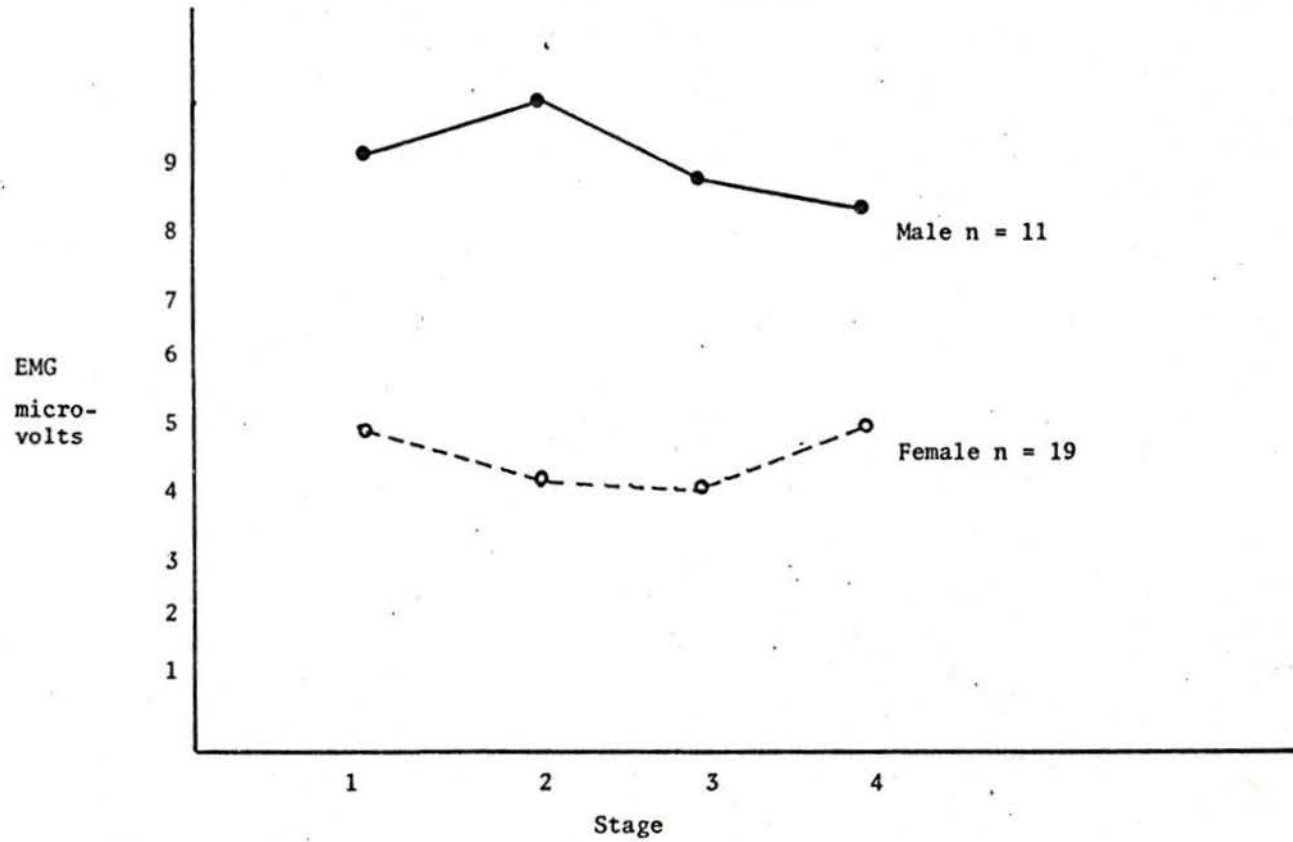
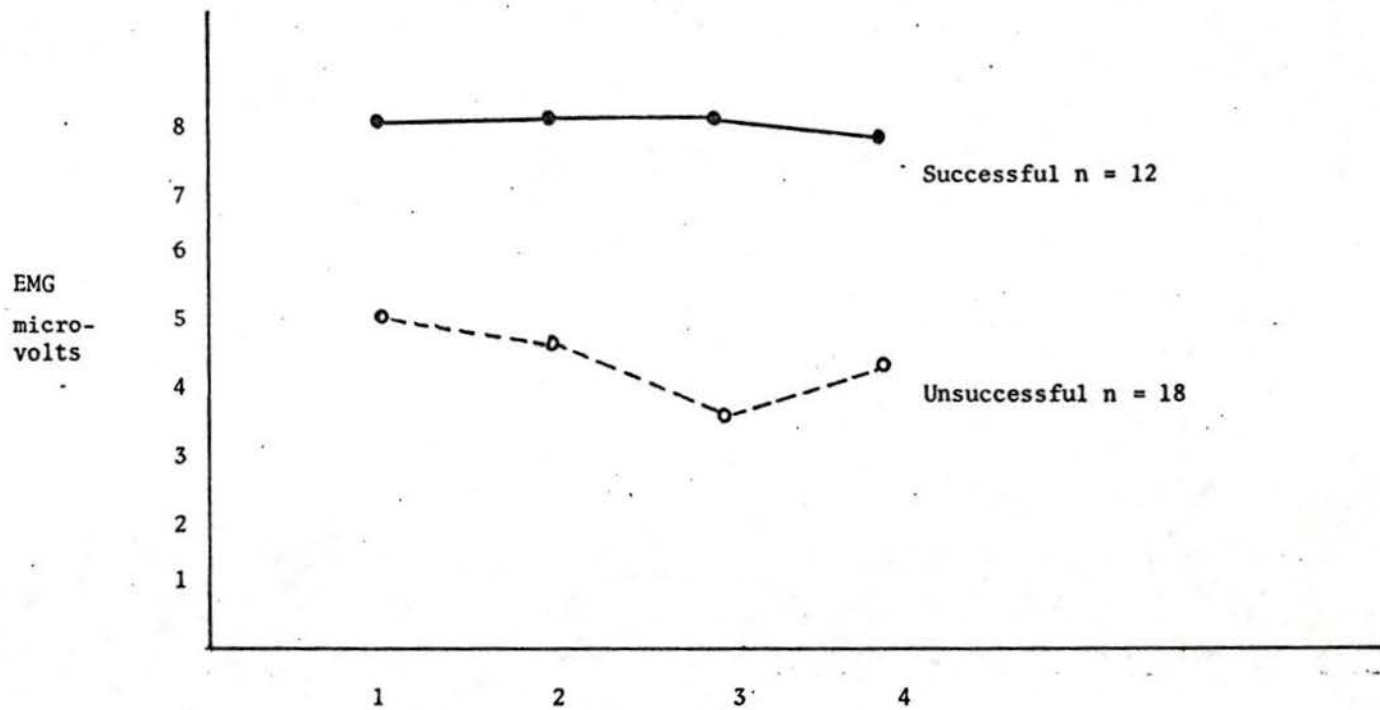


Figure 9
Averaged EMG Per Stage
Successful Group Versus Unsuccessful Group



age, weight, height, sex, occupation, and pain duration are contained in Appendices I, J, and M. EMG and pelvic tilt scores are also recorded in the above mentioned appendices. Age distribution by decade is shown in Appendix L. Both the experimental and control groups were similar in average age, weight, height, and subject distribution by sex and occupation.

Duration of pain varied from two months to 14 years among subjects. No significant correlation could be found for either the control or experimental group between pain duration and age, height, or weight. Using age, height, weight, occupation and pain duration, none were found to be predictors of pelvic tilt success (Appendix R). All the above variables together accounted for only 6 per cent of the variance when a stepwise regression analysis was run using the data from successful pelvic tilt subjects (Appendix R).

*CHAPTER V**DISCUSSION*

Research results reported in Chapter IV will be discussed with reference to the related literature. From this basis, research conclusions and recommendations will be presented.

The effectiveness of one-session electromyographic biofeedback on pelvic tilt instruction to chronic back pain patients was the focus of this study. Specifically, the clinical usefulness and applicability of the Cyborg J33 biofeedback machine to muscle re-education and movement was investigated. No other study, to the researcher's knowledge, has measured pelvic tilt response to biofeedback training after one session in the treatment of chronic back pain patients. The only other research which studied biofeedback and movement was the work of Jones and Wolf (1980). They chose to investigate one subject's response to biofeedback training during movement and muscle re-education treatment over a five week interval. They, like the researcher, were exploring an alternative method, an active one, compared, for example, to the traditional passive treatments of heat and transcutaneous nerve stimulation offered to

back pain patients.

The clinical use of biofeedback has increased in the past decade (Basmajian, 1979). It is one treatment modality compatible with the objectives of most back education courses. Both require patient involvement and self-care. In many courses, biofeedback is part of the educational program, forming the basis for relaxation training. Its use is continually evolving. This research and the literature indicate, biofeedback may serve many more functions in movement, muscle re-education and postural correction treatment.

It was the purpose of this study to determine the relative usefulness of one-session biofeedback when teaching the pelvic tilt to chronic back pain patients. In the clinical setting, one session per patient may be all that is practical. The end result desired is pain reduction and increased mobility, brought about by postural correction in all movements.

Superficially, biofeedback did not affect, in one session, a subject's ability to do a successful pelvic tilt. The results indicated a chronic low back pain subject could either initially do a pelvic tilt to the set standards or could not. The additional audio and visual cues provided by the biofeedback as opposed to no feedback, appeared to have no different effect on pelvic tilt performance.

The main variables in this study were the pelvic tilt standards, total practice time, and the number of pelvic tilt trials. While these variables were based on findings from the relaxation literature and the pilot study, their relevance to muscle re-education seems of little value.

The literature reviewed in Chapter II demonstrated many examples of the usefulness of biofeedback's visual and auditory cues for relaxation training in chronic low back pain patients. Only the recent study by Jones and Wolf (1980) has explored the use of biofeedback for muscle movement and re-education. The distinction or distinct relationship between relaxation and muscle movement and re-education may help explain the non-significant biofeedback results. The process of biofeedback for use in pelvic tilt instruction may, in reality, be more dependent on actual muscle re-education for movement than on the achievement of muscle relaxation. From this point of view, the variables mentioned previously may have been inappropriately used.

In a long term continuous situation, biofeedback was found useful in muscle re-education of a chronic low back pain patient. Jones and Wolf (1980) provided one chronic back pain patient with biofeedback for 15 sessions over five weeks. A variety of postural positions and movements were given biofeedback based on the low back muscles'

EMG activity. The subject was instructed to eliminate the biofeedback by correcting posture to reduce the electrical activity in the low back. This process was also extended into the work and home environment with the use of a portable biofeedback unit. Evaluation of performance was based on the five week change in EMG, pain, and spine and hip mobility. Jones and Wolf found a reduction in EMG and pain, accompanied by an increase in mobility.

This study, and the one by Jones and Wolf, cannot be directly compared. The research indicates a one-session attempt to change postural habits may be futile, especially in terms of muscle re-education. Jones and Wolf (1980) also found, as did this researcher, that certain movements, such as isometric contractions of the gluteus maximus, effectively reduced the EMG activity of the low back muscles. Thus, relaxation ability alone may not be the only source of potential pelvic tilt success and the reduction of EMG.

The objective of treating any low back pain patient is to reduce her/his pain and help her/him resume an active, normal lifestyle. It may not be clinically feasible, either economically or physically, to provide intensive care or evaluation to an individual for long periods of time. One session may still be useful however, if the patient is allowed to discover for her/himself what muscular movements and postural positions reduce EMG

activity, thereby possibly promoting pain reduction and increased mobility. Both this study and the one by Jones and Wolf (1980) measured EMG activity in trials from five to ten seconds per posture or movement.

For many, even unstructured efforts may prove frustrating and be of little value. EMG biofeedback could serve as a screening method to assure that only those most likely to benefit would receive the additional auditory and visual cues. EMG biofeedback would also insure a clinician's time was efficiently utilized. In this study, those subjects whose initial EMG reading was low and stayed low, were less likely to be successful pelvic tilt performers. Excessively high EMG readings were no guarantee of success either. It is only in the last five years that normative data on low back mobility and activity levels has been established by Wolf, Basmajian, and co-workers (1979, 1980).

A study by Basmajian (1978b) found, in certain instances, such as muscle spasm, the EMG activity of the lumbar regions was reduced, possibly due to the bracing effect of the muscles. In the study by Jones and Wolf (1980), the effect of biofeedback was designed to help reduce EMG activity in the low back during movement. Over time, this training helped decrease pain and increase joint mobility. Efforts to restore EMG activity to normal standards may be the best use of biofeedback, regardless

of the subject's initial lumbar EMG value.

In this study, men's EMG activity was higher than women's, $p < .05$. Wolf (1979) observed a sex-age interaction for all dynamic movements in a normal population; in rotation movements the younger men had a significantly higher EMG activity than their female counterparts. This was attributed to the men's larger muscle mass. Whether such results can be applied to the low back pain population is under clinical investigation (Wolf, 1979).

Muscle re-education and relaxation required several biofeedback sessions in spasticity control research (DeBacher, 1979). As a result of his studies, DeBacher (1979:78) concluded: "difficulty in generalization is not a limitation or shortcoming of EMG feedback." Generalizations are needed in some areas. It is difficult to specify accurately which back muscles are actively involved in any movement (Jones and Wolf, 1980). To simplify the complex nature of back pain, relationships between the many factors have been sought.

Hamilton Hall (1980), a back specialist, has tentatively found a relationship between a person's height and her/his duration of pain. No such correlation was found in this study. No predictors for pelvic tilt success could be identified. The successful group of pelvic tilt subjects did have a significantly higher EMG reading than the

unsuccessful group. A lack of predictors for back pain susceptibility or cure had plagued decades of back pain research. The complex of physiological, psychological, and anatomical considerations in back pain may defy the development of simple, concise answers. Speculation is still possible and often a useful research tool. For example, pelvic tilting, static stretching, and lumbar EMG may be related.

The successful group of pelvic tilters had a higher EMG than the unsuccessful group. For all subjects, the EMG did not significantly differ between each stage. In the research of DeVries (1968), static stretching was shown to lower the lumbar EMG of those subjects in easy standing. Perhaps this suggests the pelvic tilt is a form of static stretching. In the present study, pelvic tilting, while not lowering EMG, did not increase it either. Because low back muscle activity increased during easy standing for low back pain patients in De Vries' study, pelvic tilting may help control low back muscle activity and perhaps postural pain. The findings by Jones and Wolf (1980), support this idea. They found a lowered EMG from starting values was associated with a decrease in pain and an increase in mobility. For many of the movements required by Jones and Wolf, a pelvic tilt was used to maintain a lowered EMG.

Behaviorally, biofeedback may prove inefficient for postural control of any type unless long term and continuous in application. EMG biofeedback may serve to screen out those least able to benefit from it. In particular, low EMG activity was associated with poor performance. DeBacher (1979) recommends a hierarchy of muscle control be established along with a progression from continuous to intermittent biofeedback signal. Because individual long term biofeedback is an unlikely event, a time efficient alternative would be to use biofeedback for group demonstrations to model the importance and use of biomechanical principles. In doing so, the influence of rib cage extension, breathing, abdominal support and gluteal contraction on EMG activity and posture could be presented to a group as efficiently as in a one-to-one session.

Behavioral techniques, applied to muscle relaxation and re-education, through specific biofeedback use, can help the patient realize her/his own abilities. The need for a progression of changes to occur before the results of reduced pain and increased mobility can be realized is also underscored by biofeedback use. Biofeedback provides the patient with the opportunity to control voluntarily a variety of postural positions and movement through the additional sense information provided by the audio and visual cues. Patient control over muscle relaxation and

movement may be the important factors in the correction of stress, tension and improper posture. Biofeedback's best use may remain with providing the patient the knowledge to perform biomechanically safe movements, using correctly those muscles required to perform such movements.

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APPENDIX A

Front Panel Controls

To use the Cyborg J33, the front panel controls must be first understood as explained on page 5 of the Cyborg Booklet.

The controls on the front panel of the J33 are extremely simple. Once you understand what they do, you will have no trouble at all in operating the instrument.

The Range switch at the left of the panel selects one of three ranges: .1-10 microvolts, 1-100 microvolts, or 10-1000 microvolts. A fourth position on the switch turns off power in the instrument.

The Shaping Control, at the right of the front panel is used in setting training goals. It is calibrated to match the Range switch. (It matches perfectly, on the .1-10 range; you will have to multiply by ten for the 1-100 range, and by one hundred for the 10-1000 range).

The meter indicates the EMG level relative to the threshold setting on the Shaping Control; it provides visual feedback of changes in level; and it can be used in conjunction with the Shaping Control to determine the exact EMG level.

The Audio switch adjacent to the Shaping Control selects the type of audible feedback used. Position "A" results in a tone whose pitch increases with increasing EMG activity; position "B" results in a repetitive click whose rate increases with increasing EMG activity.

The single lamp near the bottom of the panel serves two functions: it indicates whether or not the sensors are making good contact; and it indicates when the battery is low.

APPENDIX B

Establishing EMG Baseline

The Cyborg Booklet, page 6, recommends patient baseline be established as follows:

Connect the sensors . . . set the range switch to the 1-100uV range and turn the Shaping Control fully clockwise. Instruct the subject to relax the target muscles. The meter should be left of the center mark and the audio feedback should be silent. If the meter is near or to the right of the center marks, switch to the 10-100uV range and proceed as below. Turn the shaping control counter clockwise. As you approach the baseline value the meter will move from the left toward the center of the scale. When the meter is in the center the baseline value of EMG activity can be read from the scale around the shaping control. Remember to take into account the range multiplier S1 for 1-10uV; x 10 for 1-100uV; and x100 for 10-uV range.

APPENDIX C

Data Sheet

DATA SHEET

STAGE I		STAGE II		STAGE III		STAGE IV
Erect Posture Baseline	Pelvic Tilt Treatment	Erect Posture Baseline	Pelvic Tilt Treatment	Erect Posture Baseline	Pelvic Tilt Treatment	Erect Posture Baseline
Time in Seconds	Trial Number +/-	Time in Seconds	Trial Number +/-	Time in Seconds	Trial Number +/-	Time in Seconds
EMG		EMG		EMG		EMG
10	1	10	1	10	1	10
20	2	20	2	20	2	20
30	3	30	3	30	3	30
40	4	40	4	40	4	40
50	5	50	5	50	5	50

Notes: EMG = Electrical activity of erector spinae muscles.

Stage II Biofeedback for experimental group

no biofeedback for control group

- + = successful trial, subject able to reduce by one-half baseline electrical activity of erector spinae muscles
- = unsuccessful trial; subject unable to reduce erector spinae electrical baseline by one half.

APPENDIX D

Physiotherapist's Assessment Sheet

NAME _____ AGE _____ OCCUPATION _____ DR. _____

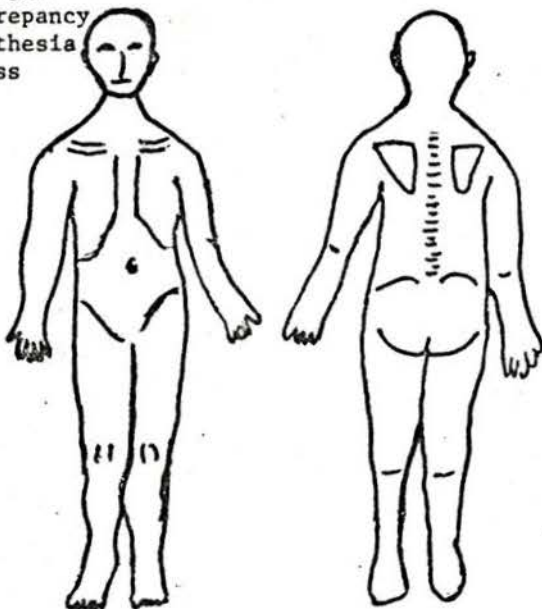
X-RAYS: _____

DATE: _____

P.T. _____

SITES OF PAIN AND PARAESTHIAE

- Bony architecture
- leg length discrepancy
- paraesthesia
- numbness



*Prominent Findings _____

Questions Related to Contraindications

- Active inflam. disease
- Dizziness - vertebral a. test
- Micturition
- Drugs
- General Health

Current HistoryPAIN

Nature _____

Constant _____ Increasing _____

Periodic _____ Static _____

Occasional _____ Decreasing _____

Night Pain _____

Rising a.m. _____

Sleeping position _____

Type of bed/mattress _____ Pillows _____

Aggravates _____

Eases _____

Sustained flexion _____ rising from _____

Sitting _____ rising from _____

Cough/Sneeze _____ Deep Breath _____

Day Pain (overall) _____

evening _____ Irritability _____

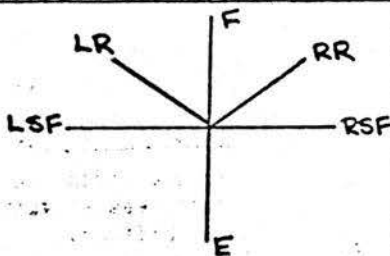
Previous History, Treatment and Result

Hobbies, Pastimes Etc. _____

Spinal Articular Signs and Isometric Testing

Architectural Scan

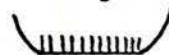
F.
LSP.
RSF.
E.
L.R.
RR.



Traction Neutral _____
 flexion _____
 Extension _____
 Compression Neutral _____
 Flexion _____
 extension _____
 Foraminal Compression _____
 Chest Expansion _____

Palpation Findings

P - Pain
 ps - Paraesthesia
 X - Stiff Segment
 III- Thickened (deep)
 Z - Elicited Spasm
 - Hypermobile Segment



--1--
 --2--
 --3--
 --4--
 --5--
 --6--
 --7--
 --1--
 --2--
 --3--
 --4--
 --5--
 --6--
 --7--
 --8--
 --9--
 --10--
 --11--
 --12--
 --1--
 --2--
 --3--
 --4--
 --5--

Other Tests

Lower Limb

SLR & Bowstring
 Passive Neck Flexion
 Femoral Nerve Stretch
 T1 Dural Stretch
 S.I.

Hip

Knee

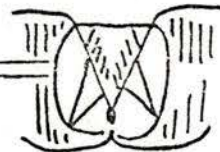
Foot & Ankle

Upper Limb

A/C
 S/C
 Shoulder
 Elbow
 Wrist
 Hand

REFLEXES

Biceps _____ Triceps _____
 Brachiorad _____ Quads _____
 Achilles _____ Hams L5 _____
 Plantar _____ Finger tips C8T1 _____



Neurological Examination

Weakness

C1,2 Head Nodding _____
 C1,2,3 Neck Flexion and Ext. _____
 C3,4 Shoulder Girdle Elev. _____
 C4 Diaphragm _____
 C5 (6) Deltoid _____
 C6 Biceps _____
 C7,8 (6) Triceps _____
 C8 Ext. Pollicis Long _____
 T1 (8) 3rd and 4th palmar interossei _____

L2 Psoas _____
 L3 Quadriceps _____
 L4 Tib Ant. _____
 L5 Ext. Hall. Long. _____
 L5,S1 Toe Ext. _____
 L5,S1 Peronei _____
 L5,S1,2 Calf-Hamstrings _____
 Wasting _____
 Sensation _____

REMARKS (Social History etc.)

APPENDIX E

Letter to Low Back Pain Patients

May - June, 1980

School of Physical Education

TELEPHONE (604) 477-6911, TELEX 049.7222



University of Victoria
P.O. BOX 1700, VICTORIA
BRITISH COLUMBIA, CANADA
V8W 2Y2

Dear

Your participation as a volunteer is requested for a University of Victoria research project to be conducted at the Gorge Road Hospital. The research has been approved by the hospital and is designed to evaluate a new treatment procedure recently incorporated into the Gorge Road Hospital Back Education Program. Volunteers are needed who have not taken the course, nor been exposed to the new treatment procedure. This research project offers participants an interesting educational experience with no discomfort.

Approximately forty-five minutes of your time is required during which one-half hour will be devoted to individual instruction, measurement and practice of proper posture. You will receive a phone call to confirm receipt of this letter and if appropriate to set a convenient appointment time.

Your participation will not only benefit yourself, but the hospital as well. The research results will provide information of interest to the back care program in its continual endeavor to promote successful clinical outcomes.

Sincerely,

Handwritten signature of Charlene D. Glasser in cursive.

Charlene D. Glasser
University of Victoria

Handwritten signature of Martin L. Collis in cursive.

Martin L. Collis
Professor,
University of Victoria

APPENDIX F

Pelvic Tilt Instructions

The pelvic tilt will be taught to each subject, first supine and then standing, using the following as instructional cues.

Fahrni, W.

Gently tighten the abdominal and buttock muscles so that the low back flattens.

Schering

To find the correct standing position: stand one foot away from wall. Now sit against wall, bending knees slightly. Tighten abdominal and buttock muscles. This will tilt the pelvic back and flatten the lower spine. Holding this position, inch up the wall to standing position, by straightening the legs. Now walk around the room, maintaining the same posture. Place back against wall again to see if you have held it.

Workers' Compensation Board of British Columbia

The pelvic tilt strengthens the muscles that control the pelvis, mobilizes joints and teaches pelvic control. It is especially good for swaybacks.

Slowly tighten the buttock muscles and pull in the abdomen.

APPENDIX G

Biofeedback and EMG Determination

Electrical Reduction Training

The Cyborg Booklet instructs on page 6:

Once an approximate baseline has been determined, you can establish training goals above or below present activity by adjusting the shaping control.

If you are trying to decrease muscle activity (as in relaxation training), turn the shaping control counterclockwise until the meter is right of center (about 1.5-2.0). Now as the subject decreases muscle activity, the meter will move to the left, and the audio feedback changes (decreased pitch, or decreased repetition rate of clicks); with further decrease in muscle activity, the meter reaches center, and the audio feedback shuts off, indicating the setting on the shaping control has been reached.

EMG Determination

When the J33 is being used on a subject, the exact value of EMG voltage can be determined from the meter, the Shaping Control, and the Range switch jointly. Adjust the Shaping Control until the meter reads exactly XI--the central position on the scale--then read the value from the Shaping Control, remember to take the Range into account.

APPENDIX H

Skin and Sensor Preparation for
Sensor Placement

Convenient Disposable Sensors

The Cyborg EMG sensors and accessories manual on page 3 describes the Quick Stick flexible sensors used.

They contain three sensors and have built-in adhesives. These sensors are suitable for all relaxation training applications as well as for muscle re-education applications involving large muscles or muscle groups. The Quick-Stick sensor, with convenient snap connectors, gives you quick and easy attachment. This ease of attachment also makes the Quick-Stick ideal for patient home use. Anyone of the three sensor spacings may be varied for convenience. Where wider spacing is desired, strips may easily be cut apart and the sensors placed individually.

Skin Preparation

The Quick Stick flexible sensors on a strip will standardize sensor placement on either side of the fourth lumbar vertebrae. The skin sites will be cleaned with alcohol and then rubbed with an abrasive pad to remove skin oils and dead skin which can impede contact. Sensor gel will next be applied to the three sensors and leveled off with the edge of sensor. The paper backing will be peeled off and the built in adhesive will allow a firm contact between sensors and the skin and quick attachment. The snap connector designated as the ground will be

connected to the sensor on the lumbar four vertebrae.

APPENDIX I

Control Group Data

CONTROL GROUP DATA

SUCCESSFUL PELVIC TILT PERFORMANCE

Subject	Sex	Age in Years	Height in Meters	Weight Kilograms	Occupation ¹	Pain in Months	Pelvic Tilt ² Stage 1	Pelvic Tilt Stage 2	Pelvic Tilt Stage 3	EMG Stage 1	EMG Stage 2	EMG Stage 3	EMG Stage 4
										in microvolts			
1	M	25	1.75	78.2	1	3	5	5	2	6.00	5.00	5.00	7.00
3	F	66	1.57	49.9	3	24	0	1	0	7.40	6.20	9.00	5.00
7	M	26	1.71	76.2	1	12	3	5	1	9.00	18.00	20.00	21.00
9	M	36	1.88	79.4	5	7	0	0	3	9.80	15.00	14.00	7.20
11	F	52	1.65	58.1	2	5	4	1	0	9.20	6.00	10.00	9.60
12	F	42	1.82	57.6	12	276	1	0	0	6.00	3.40	3.70	3.70
15	M	31	1.85	72.6	14	2	0	0	1	6.00	5.40	5.80	4.20

UNSUCCESSFUL PELVIC TILT PERFORMANCE

2	F	58	1.60	59.0	4	11	0	0	0	1.50	2.40	1.94	1.60
4	F	35	1.68	64.4	2	132	0	0	0	3.90	3.60	3.90	3.55
5	F	34	1.67	59.0	6	84	0	0	0	5.20	4.20	4.40	5.00
6	F	62	1.60	61.2	3	96	0	0	0	4.00	4.00	2.00	2.00
8	F	54	1.64	52.2	3	120	0	0	0	2.00	2.50	3.00	3.00
10	M	45	1.80	115.7	11	4	0	0	0	9.00	7.00	7.00	7.20
13	M	26	1.73	86.2	13	2	0	0	0	3.00	2.40	3.00	3.50
14	F	18	1.70	72.6	6	12	0	0	0	2.90	2.60	2.10	2.50

Notes: ¹Occupational list in appendix.

²No biofeedback in any stage of pelvic tilt treatment.

³EMG score is average of five recordings taken at ten second intervals for one minute prior to each pelvic tilt treatment in Stages 1, 2, 3 and by itself in Stage 4.

APPENDIX J

Experimental Group Data

EXPERIMENTAL GROUP DATA

SUCCESSFUL PELVIC TILT PERFORMANCE

Subject	Sex	Age in Years	Height in Meters	Weight in Kilograms	Occupation ¹	Pain in Months	Pelvic Tilt Stage 1	Pelvic Tilt Stage 2	Pelvic Tilt Stage 3	EMG Stage 1	EMG Stage 2 in microvolts	EMG Stage 3	EMG Stage 4
3	M	42	1.74	70.3	5	6	3	5	5	4.90	6.00	8.00	6.40
5	F	55	1.66	76.7	3	5	5	5	5	5.60	5.40	5.80	5.80
13	F	50	1.64	54.4	4	6	5	5	5	10.00	8.00	7.60	8.00
14	F	35	1.60	58.1	4	168	0	1	2	14.00	10.00	6.00	8.00
15	F	45	1.57	77.1	4	30	1	3	3	9.00	9.00	3.00	7.00

UNSUCCESSFUL PELVIC TILT PERFORMANCE

1	M	42	1.88	88.5	1	6	0	0	0	9.00	4.00	4.00	9.00
2	F	39	1.68	64.9	4	2	0	0	0	2.00	2.50	2.00	2.00
4	F	57	1.65	56.2	3	120	0	0	0	2.10	2.30	2.40	7.00
6	F	26	1.68	57.2	3	9	0	0	0	2.00	2.00	2.00	2.00
7	M	29	1.80	83.9	7	11	0	0	0	30.00	30.00	15.00	12.00
8	M	24	1.82	77.1	8	2	0	0	0	7.40	8.00	9.00	9.00
9	F	69	1.52	59.0	9	84	0	0	0	2.00	2.00	2.00	2.00
10	M	24	1.72	74.8	10	108	0	0	0	2.60	2.60	2.00	2.60
11	F	36	1.66	63.5	2	6	0	0	0	3.00	3.29	3.00	2.95
12	F	55	1.68	61.7	2	30	0	0	0	2.00	2.20	4.00	4.00

Notes: ¹Occupational list in appendix.

²Biofeedback used in this pelvic tilt treatment in Stage 2.

³EMG score is average of five recordings taken at ten second intervals for one minute prior to each pelvic tilt treatment in Stages 1, 2, 3, and by itself in Stage 4.

APPENDIX K

Subject Characteristics

Subject Characteristics

<u>Age</u>	<u>Range</u>	<u>Mean</u>	<u>Standard Deviation</u>
Total	18-69	41.60	+ 13.64
Experimental	24-69	42.53	+ 12.72
Control	18-66	40.66	+ 14.89
Successful	25-66	42.08	+ 12.31
Unsuccessful	18-69	41.27	+ 14.80

<u>Sex</u>	<u>Female</u>	<u>Male</u>	<u>Total</u>
Total	19	11	30
Experimental	10	5	15
Control	9	6	15
Successful	7	5	12
Unsuccessful	12	6	18

<u>Weight in Kilograms</u>	<u>Range</u>	<u>Mean</u>	<u>Standard Deviation</u>
Total	49.9-115.7	68.85	+ 13.88
Experimental	54.4-88.5	68.22	+ 10.87
Control	49.9-115.7	69.48	+ 16.73
Successful	49.9-79.4	67.38	+ 10.86
Unsuccessful	52.2-115.7	69.83	+ 15.80

<u>Height in Meters</u>	<u>Range</u>	<u>Mean</u>	<u>Standard Deviation</u>
Total	1.52-1.88	1.90	+ .09
Experimental	1.52-1.88	1.68	+ .09
Control	1.57-1.88	1.71	+ .09
Successful	1.57-1.98	1.70	+ .11
Unsuccessful	1.52-1.88	1.69	+ .08

<u>Pain Duration in Months</u>	<u>Range</u>	<u>Mean</u>	<u>Standard Deviation</u>
Total	2-276	46.10	+ 65.60
Experimental	2-168	38.73	+ 53.74
Control	2-276	52.66	+ 77.34
Successful	2-276	45.33	+ 86.00
Unsuccessful	2-132	46.61	+ 50.63

APPENDIX L

Age By Decade And By Sex

AGE BY DECADE AND BY SEX

	EXPERIMENTAL			CONTROL			TOTAL			SUCCESSFUL PT		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
18-29	2	1	3	3	1	4	5	2	7	2		2
30-39	1	3	4	2	2	4	3	5	8	2	1	3
40-49	2	1	3	1	1	2	3	2	5	1	2	3
50-59		4	4		3	3		7	7		3	3
60+		1	1		2	2		3	3		1	1
	5	10	15	6	9	15	11	19	30	5	7	12

APPENDIX M

Occupations

OCCUPATIONS

		<u>Total</u>
1	Laborer	3
2	Office worker	4
3	Houseperson	6
4	Medical worker, nurse, physiotherapist	5
5	Teacher	2
6	Waitress, restaurant worker	2
7	Logger	1
8	Painter	1
9	Retired	1
10	Technician, medical	1
11	Engine fitter	1
12	Pre-school supervisor	1
13	Mill worker	1
14	Truck driver	1

APPENDIX N

Averaged EMG For:

*Control Group versus
Experimental Group*

*Successful Group versus
Unsuccessful Group*

*Female Group versus
Male Group*

AVERAGED EMG

MEANS AND STANDARD DEVIATIONS PER STAGE AND IN TOTAL

Stage	I	II	III	IV	Total	Median
Experimental	7.34	6.48	5.05	5.85	6.11	4.45
SD	<u>+7.37</u>	<u>+7.07</u>	<u>+3.65</u>	<u>+3.12</u>		
Control	5.67	5.85	6.32	5.74	5.89	4.70
SD	<u>+2.74</u>	<u>+4.60</u>	<u>+5.09</u>	<u>+4.78</u>		
Successful	8.08	8.12	8.16	7.74	8.02	
SD	<u>+2.60</u>	<u>+4.36</u>	<u>+4.78</u>	<u>+4.50</u>		
Unsuccessful	5.21	4.97	4.03	4.49	4.65	
SD	<u>+6.63</u>	<u>+6.50</u>	<u>+3.33</u>	<u>+3.06</u>		
Female	4.9	4.29	4.25	4.56	4.49	
SD	<u>+3.51</u>	<u>+2.48</u>	<u>+2.43</u>	<u>+2.44</u>		
Male	8.79	9.4	8.44	8.10	8.68	
SD	<u>+7.45</u>	<u>+8.4</u>	<u>+5.65</u>	<u>+5.05</u>		
TOTAL	6.36	6.16	5.68	5.79	6.0	

APPENDIX O

Pelvic Tilt Analysis of Variance

PELVIC TILT ANALYSIS OF VARIANCE

Source	DF	SS	MS	F	P Less Than
<u>Between Subjects</u>					
Group 1	1	4.9000	4.9000	.6022	.4442
Error Term	28	227.8222	8.1365		
<u>Within Subjects</u>					
PT	2	.3556	.1778	.2825	.7550
Group x PT	2	2.4000	1.2000	1.9067	.1581
Error Term	56	35.2444	.6294		
Total	89	270.7222	3.0418		

APPENDIX P

*Averaged EMG Analysis of Variance for
Experimental and Control Groups*

EMG ANALYSIS OF VARIANCE

Source	DF	SS	MS	F	P Less Than
<u>Between Subjects</u>					
Group	1	1.3356	1.3356	.0159	.9005
Error Term	28	2348.1865	83.8638		
<u>Within Subjects</u>					
EMG Stage	3	8.8183	2.9394	.4723	.7024
Group x EMG Stage	3	27.8614	9.2871	1.4923	.2225
Error Term	84	522.7667	6.2234		
Total	119	2908.9686	24.4451		

APPENDIX Q

*Analysis of Variance for Averaged EMG by
Successful Versus Unsuccessful and Female Versus Male Groups*

SUCCESSFUL VERSUS UNSUCCESSFUL

EMG ANALYSIS OF VARIANCE

Source	SS	DF	MS	F	P Less Than
Within Cells	505.683	28	18.060		
Between Groups	81.911	1	81.911	4.535	.042

for 30 observations

FEMALE VERSUS MALE

EMG ANALYSIS OF VARIANCE

Source	SS	DF	MS	F	P Less Than
Within Cells	3038.197	118	25.747		
Between Groups	282.934	1	282.934	10.99	.01

for 120 observations

APPENDIX R

*Multiple Regression And Correlation
Coefficients For Successful Group Data*

MULTIPLE REGRESSION USING SUCCESSFUL GROUP DATA

Variable	Multiple R	R Square	RSQ Change	Simple R	R
WT	0.08814	0.00777	0.00777	0.08814	0.12555580-01
Sex	0.23849	0.05688	0.04911	-0.08472	-0.3345927
Age	0.24930	0.06215	0.00527	-0.02942	-0.38079980-02
Pain	0.25051	0.06275	0.00061	0.00969	0.27325740-03
HT	0.25150	0.06325	0.00050	-0.03972	-0.2153561
OCC	0.25248	0.06375	0.00049	0.00000	0.20092880-01
(Constant)					1.660697

CORRELATION COEFFICIENTS USING SUCCESSFUL GROUP DATA
(n = 12)

	Group	Age	HT	WT	OCC	Sex	Pain
Group	1.00000	-0.02942	-0.03972	0.08814	0.00000	-0.08472	0.00969
Age	-0.02942	1.00000	-0.56851	-0.39951	0.57277	-0.50324	0.18314
HT	-0.03972	-0.56851	1.00000	0.60570	-0.54062	0.74931	-0.15023
WT	0.08814	-0.39951	0.60570	1.00000	-0.63416	0.73731	-0.40741
OCC	0.00000	0.57277	-0.54062	-0.63416	1.00000	-0.66087	0.23386
Sex	-0.09472	-0.50324	0.74931	0.73731	-0.66087	1.00000	-0.36854
Pain	0.00969	0.18314	-0.15023	-0.40741	0.23386	-0.36854	1.00000

VITA

Surname: GLASSER Given Names: CHARLENE DARYL

Place of Birth: LONG BEACH, CALIFORNIA Date of Birth: AUGUST 16, 1950

Educational Institutions Attended, with Dates of Entering and Leaving:

UNIVERSITY OF CALIFORNIA, BERKELEY, USA 1968 to 1972

UNIVERSITY OF BRITISH COLUMBIA, B.C. CANADA 1972 to 1973

UNIVERSITY OF VICTORIA, B.C. 1978 to 1980

Degrees, Diplomas, Etc., Awarded, with Dates and Names of Institutions:

B. Sc. (Honours) 1972 University of California, Berkeley USA

Honours and Awards:

Honours at Entrance, University of California, 1968; California State

Scholarship, 1968/69, 1969/70, 1970/71, 1971/72; Berkeley Alumni

Scholarship, 1968/69; Xi Sigma Pi Freshman Award in Forestry, 1969;

Walter Mulford Forestry Scholarship 1970/71 and 1971/72; Xi Sigma

Pi Outstanding Senior Award, 1972; Van Dusen Forestry Fellowship,

1972/73; University of Victoria Fellowship, 1979/80.

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ON PELVIC TILT PERFORMANCE IN CHRONIC LOW BACK PAIN PATIENTS

Author



Signature

CHARLENE DARYL GLASSER

Name

February 9, 1981

Date