White Paper:
Clinical Efficacy of Psychophysiological Assessments and Biofeedback Interventions for Chronic Pain Disorders
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ABSTRACT

Psychophysiological assessments and biofeedback based interventions for disorders whose main symptom of interest is chronic pain can be highly effective and useful in the clinical environment. The evidence supporting the effectiveness of psychophysiological assessments and interventions for phantom limb pain, upper and lower back pain, non-cardiac chest pain, and pelvic floor pain disorders is reviewed to provide examples of how these techniques are applied to problems having differing etiologies. There is a dearth of controlled studies in this area so the supporting evidence is not as strong as it might be given the clear clinical utility of the techniques. The evidence from formal studies shows that efficacy ranges from efficacious (e.g., irritable bowel syndrome, migraine and tension headaches) through probably efficacious (e.g. back pain, phantom limb pain) and possibly efficacious (e.g., Raynauds syndrome) to not empirically supported (e.g. Reflex Sympathetic Dystrophy).
OVERVIEW

Although pain accompanies numerous chronic disorders, for many, pain is the symptom of concern to both the sufferers and their therapists. Examples of such disorders are headache, phantom limb pain, and reflex sympathetic dystrophy. The underlying pathophysiology of these disorders is seldom well understood and similar symptom complexes are frequently caused by different underlying problems. Thus, patients with ostensibly similar symptoms may have very different disorders. For example, phantom limb pain can be caused by at least three mutually exclusive physiological problems in the residual limb including spasms in key muscles, insufficient blood flow, and trigger points. For many of these disorders, such as reflex sympathetic dystrophy (RSD), there is little relationship between ongoing tissue damage and extent of pain. In other words, pain may not be an accurate warning that continued activity will cause additional damage to the body.

Chronic pain commonly stems from specific physiological imbalances such as: (1) tension maintained at too high a level for too long and / or spasms in specific muscles as may be found in cramping phantom limb pain, or (2) significantly decreased blood flow to a specific area as may be found in early RSD and Raynaud’s syndrome.

Stress responses and anxiety frequently magnify or cause intermittent chronic pain. For example, non-cardiac chest pain often occurs due to incorrect breathing patterns which cause anxiety. The pain, of course, results in more anxiety which then magnifies the pain. As will be discussed later, correction of the incorrect breathing patterns has been shown to resolve the anxiety and eliminate the non-cardiac chest pain. As Yucha and Gilbert (2004) point out, chronic pain can be widespread at least partially due to such factors as neural sensitization, altered neurotransmitter levels, inflammation, muscle guarding, magnification through mechanisms noted above, etc. Thus, chronic pain can not always be tied to one precipitating incident and rectification of one cause may not end pain which has become pervasive.

As might be imagined, chronic pain disorders are far more amenable to successful intervention when the underlying physiological dysfunctions can be identified and changes in those dysfunctions tracked through treatment attempts. For example, treatments of cramping and burning phantom limb pain have abysmal seven percent success rates when underlying mechanisms are ignored, but about ninety percent success rates when treatments are aimed at correcting the specific dysfunctions underlying each descriptor (Sherman, Devor, Jones, Katz, &
Psychophysiological assessments have been shown to provide uniquely objective ways to demonstrate relationships between underlying physiological problems and the resulting pain. This information can be used to: (1) track changes in the underlying pathophysiology, and (2) provide information for self control strategies so the therapist and patient can tell exactly how the physiology is responding in real time. For example, Figure One illustrates how psychophysiological recordings are used to track changes in a disorder over time. This figure shows how changes in near surface blood flow coincide with changes in the intensity of burning phantom pain (Sherman, Devor, Jones, Katz, & Marbach, 1996). Figure Two illustrates how these recordings are used to demonstrate physiological changes resulting from biofeedback interventions (Sherman, Evans, & Arena, 1993). It shows the differences in shoulder area muscle tension patterns before and after biofeedback training.

There is far too much information available on too many chronic pain disorders to cover all of them here. This paper uses four disorders -- phantom limb pain, musculoskeletal back pain, pelvic floor pain, and non-cardiac chest pain -- to exemplify the evidence and logic for using psychophysiological assessments and biofeedback interventions for pain problems having varied etiologies including vascular dysfunctions, muscular dysfunctions, postural problems, and anxiety/stress responses. Citations were gleaned from searches of: (1) the National Library of Medicine’s data bases, (2) the web, and (3) indexes of journals frequently publishing biofeedback related articles.

Readers wanting further information on the plethora of disorders amenable to psychophysiological assessment interventional techniques are referred to the book *Pain Assessment and Intervention from a Psychophysiological Perspective* (Sherman, 2004). Tan, Sherman, and Shanti (2003) recently summarized the overall logic for using biofeedback to treat chronic pain disorders and assessed the effectiveness of biofeedback for those disorders. Specific reviews of the efficacy of biofeedback for the treatment of headaches, irritable bowel syndrome, facial pain, and Raynaud’s syndrome are provided by Yucha and Gilbert (2004).
Figure One. Relationship between intensity of burning phantom pain and near surface blood flow. The figure shows redrawn color videothermograms of an amputee missing the index finger on the left hand. Size of dots represents relative warmth at the skin’s surface with the largest dots showing the most warmth and blank areas being coolest. Blank areas are essentially the same temperature as the surrounding room. Burning phantom pain intensity is rated on a scale of 0 - 10.
Figure Two. **Relationships between trapezius EMG and tension headache intensity recorded in a subject's normal environment before and after muscle tension awareness and control training.** Before training the signal is relatively high and doesn’t change much over time. After training the signal is (a) generally lower in tension, (b) much more responsive and correlates well with task intensity, and (c) there are also periods of very low tension. (Simulation derived from a compilation of raw data). Time scale is approximately 1 hour per cm.
TYPICAL PAIN DISORDERS TREATED USING BIOFEEDBACK

Phantom limb pain, musculoskeletal back pain, pelvic floor pain, and non-cardiac chest pain are presented to exemplify the evidence and logic for using psychophysiological assessments and biofeedback interventions for pain problems having varied etiologies including vascular dysfunctions, muscular dysfunctions, postural problems, and anxiety/stress responses.

1. Phantom Limb Pain

Phantom limb pain is used an example for the integration of psychophysiological assessment techniques with biofeedback interventions. Patient selection criteria and assessment protocols are briefly described. These techniques parallel those for the other chronic pain conditions discussed in the paper, so will not be detailed elsewhere.

Overview: The evidence supporting the use of applied psychophysiological techniques for the treatment of phantom limb pain comes from two directions. The first consists of a solid body of clinical research which establishes psychophysiological mechanisms for the burning and cramping descriptors of phantom pain. Both the mechanisms and the symptoms are responsive to applied psychophysiological interventions. The second consists of a few uncontrolled efficacy studies combined with moderately widely replicated clinical experience supporting the effectiveness of psychophysiological techniques in correcting the problems identified in the mechanism literature. The literature on both mechanisms and treatment is complex, contradictory, and potentially misleading. Anyone seriously interested in tackling phantom limb pain on a regular basis would be well advised to read one of the reviews of the field such as that by Sherman (1994). For an 'in depth' look at the entire area of phantom pain, one might read the book *Phantom Pain* by Sherman, , Devor, Jones, Katz, & Marbach,1996.

Psychophysiological Mechanisms: Numerous studies have demonstrated that phantom pain described as burning and tingling is related to decreased blood flow in the residual limb, while phantom pain described as cramping is related to high frequency spasms in the residual limb. No studies have demonstrated underlying physiological mechanisms for the relatively rare phantom pain described as shocking and shooting (Sherman, 1996).
Efficacy Studies: This review of efficacy studies is adapted with modifications from Sherman, et al., 1996.

Relationships between Description of Phantom Pain and Type of Treatment Likely to Succeed: Several small studies summarized in Sherman (1996) have related the effectiveness of behavioral and medical treatments of phantom pain to underlying physiological correlates. When research on amputees demonstrated that decreased blood flow in the stump was related to increased burning phantom limb pain, peripheral vasodilators and temperature biofeedback were used to decrease the phantom pain. When increased muscle tension and spasms in the stump were related to episodes of cramping phantom pain, muscle relaxants and muscle tension biofeedback were used to control the pain.

Researchers found EMG biofeedback to be effective for thirteen of fourteen trials for cramping phantom pain. EMG biofeedback had minimal success with two and no success with ten of twelve trials for burning phantom pain. It had no success with eight trials of shocking phantom pain. Temperature biofeedback was ineffective for four trials of cramping phantom pain, was effective for six of seven trials with burning phantom pain, and had no success with three trials for shocking phantom pain. Nitroglycerine ointment (a topical vasodilator) was ineffective for one trial of cramping phantom pain and one of shocking phantom pain but successful for two trials of burning phantom pain.

Trental (a blood viscosity enhancer) was ineffective for two trials of cramping phantom pain and one of shocking phantom pain. Nifedipine (a systemic vasodilator) was effective for three trials of burning phantom pain but ineffective for one trial of cramping and two trials of shocking phantom pain. Flexeril (a muscle relaxant) was effective for two trials of cramping phantom pain but ineffective for one with shocking phantom pain. Indocin (an anti-inflammatory agent) was ineffective for two trials of cramping phantom pain. The overall conclusion from this investigation is that varying types of phantom pain respond virtually only to interventions which alter the underlying mechanisms.

Follow-up Durations: Only one study with significant follow-ups has been reported (Cf., review in Sherman, , Devor, Jones, Katz, & Marbach, 1996). Use of EMG biofeedback combined with
home use of progressive muscle relaxation exercises showed excellent success with six month to three year follow-up for fourteen of sixteen successive phantom pain patients.

**Treatment Success vs. Learning to Control the Appropriate Physiological Parameter:** The major difference between those patients in the above study who succeeded in learning to control their pain and those who did not was the ability to relax in any measurable way. The two failures neither (a) demonstrated the ability to relax, nor (b) reported subjective feelings which would be associated with learning to relax or to control their muscle tensions.

**Recommended Interventions:** These recommendations were adapted with modifications from Sherman, et al. (1996). It is clear that burning phantom pain responds to interventions which increase blood flow to the residual limb while cramping phantom pain responds to interventions which decrease tension and spasms in major muscles of the residual limb. Shocking and shooting phantom pain does not respond well or consistently to either type of intervention. It is recommended that biofeedback of appropriate parameters be used in conjunction with other self-control training strategies to treat cramping/squeezing and burning/tingling phantom limb pain.

It is important for clinicians to recognize that biofeedback as utilized for control of phantom limb pain is not some kind of black box magic. Rather, it is simply the process of recording the physiological parameters (such as muscle tension in the residual limb) which precede changes in phantom pain, and showing these signals to patients. The patient uses the information to change the signal. The patient also learns to associate sensations related to onset of phantom pain with tension in the muscle, decreased blood flow, etc. and to use the learned ability to control the parameter to prevent the onset of or to stop it if it has already begun. Ten one-hour long sessions are typically required for efficacy.

**Treatment Protocols for Burning Phantom Pain.** If the patient reports burning phantom pain (including tingling and similar descriptions), increased phantom pain with decreased atmospheric temperature, or decreased stump temperature before an increase in phantom pain, first conduct a trial of temperature biofeedback from the residual limb in conjunction with relaxation training containing warming exercises. If this is not effective, undertake a trial with peripheral vasodilators (such as nitroglycerine paste applied to the distal end of the residual limb) and, if
necessary, multiple sympathetic blocks. Single blocks tend to be of short duration and ineffective as a treatment, but may be a useful diagnostic tool.

**Treatment Protocols for Cramping Phantom Pain.** If the patient reports cramping phantom pain (including twisting, gripping, etc.) or the stump shows spikes in the EMG and/or spasms during phantom pain, conduct a trial of muscle tension biofeedback from the residual limb in conjunction with muscle tension awareness and control training. If this is not effective, conduct a lengthy trial with muscle relaxants.

2. **Upper And Lower Back Pain**
**(Including Pain Due To Postural Problems):**

**Rationale:** Psychophysiological assessments and biofeedback interventions are most effective for muscle related back pain. The following section is taken almost verbatim from *Pain Assessment and Intervention* (Sherman 2004). Relationships between sustained level of muscle contraction and occurrence of pain in the back are not well understood and the literature is confusing. For example, Basmajian (1981), Wolf and Basmajian (1979), and Kravitz, Moore, and Glaros (1981) found that the paralumbar muscles of relaxed low back pain patients were less contracted than those of "normal" controls. Collins, Cohen, Naliboff, and Schandler, (1982) found that in the standing position, the tension in the paraspinal muscles of low back pain subjects was similar to that in controls. Many other groups have reported similar findings while at least as many have reported just the opposite under apparently similar recording conditions. Hoyt, Hunt, DePauw, Bard, and Shaffer (1981) showed that surface EMGs of low back pain patients differ most from those of normals for the standing positions with low back pain patients being tenser by one third to one half. These types of results have been reported by many others including Grabel (1974), who also found that there were no differences in tension in response to simulated psychological stresses between groups with and without low back pain. Dorpat and Holmes (1952) did find such a relationship among several patients identified as having both high levels of anxiety and back pain. With the important exception of Dorpat and Holmes' few subjects, none of the research groups divided their subjects by diagnosed etiology of their
subjects' pain. Many groups (e.g., Cram & Steger, 1983) have found trends toward asymmetry in muscle tension in the left vs. right sides of the low back among subjects with low back pain.

Many psychological factors complicate the relationship between reported intensity of low back pain and paraspinal EMG. Psychological influences on perception of pain intensity are especially difficult to evaluate. For this reason, our research design eliminates all subjects with significantly abnormal psychological patterns from our studies and require all subjects to keep logs of their perceived stress intensities (Sherman, et al., 1992, 1993, 1996). For example, Ahles (personal communication, 1989) reviewed findings from such workers as Flor, Turk, and Birbaumer (1985) and Dickson-Parnell and Zeichner (1988) and concluded that personally relevant stressors produce elevations in paraspinal EMG levels which distinguish low back pain patients from non-pain controls.

Sherman (1985) showed that much of the confusion and high variability in reports of muscle tension in back pain is caused by (1) recording all of the subjects in only one or two positions regardless of the most painful position, and (2) recording the subjects only once without regard to current level of pain. He showed that a consistent relationship exists between low back pain intensity and muscle tension when they recorded each subject in six different positions and at differing pain intensities. One hundred and twenty-six subjects participated in the study. Each was recorded while standing, sitting supported and unsupported, prone, bending, and rising. Recordings were performed on days when subjects were at various pain intensities. Each subject reporting pain at the time of recording showed one or more position in which their muscle tension was different from that of controls. When the "low back pain" subjects were recorded without pain, their recordings were similar to those of the controls. For those positions in which a subject showed abnormal muscle tension, there was a high correlation between reported pain intensity and number of microvolts showing in the recordings over the series of recordings (Spearman's Rho = 0.92). Since that time, an additional 256 subjects have been recorded. Each subject had medical diagnoses based on thorough orthopedic tests. The original findings have been confirmed and it has been determined that there are significant differences in muscle tension among pain free controls, subjects with muscle related back pain, and subjects with diagnoses not related to muscle tension (Arena, Goldberg, Saul, & Hobbs 1989). The
electromyographic recording techniques are consistent between recordings so the results are not significantly confused by unrecognized factors (Arena, Sherman, Bruno, & Young, 1988).

Herta Flor and Niels Birbaumer (Flor & Birbaumer, 1994) concluded that chronic musculoskeletal pain, in the absence of an obvious, current precipitating factor, is likely to have any of several potential bases:

**Pain Causes Sympathetic Activation and Reflex Muscle Spasms:** The sympathetic activation combined with the pain resulting from the reflex muscle spasms could cause a conditioned response to “innocuous stimuli present in the pain-eliciting situation.” Thus, the reactions to innocuous stimuli, such as pressure on muscles that spasmed when they were acutely hurt, would cause a conditioned reflex and set of spasms. Gevirtz and his group (e.g. Lewis et al 1994) have now shown that sympathetic activation of spinal fibers in muscles related to the vestibular system (such as the trapezius) can cause muscle contraction. Thus, the proposed reaction is essentially doubled in magnitude for those areas such as the shoulder muscles that have sympathetically innervated spindle fibers. Flor's group has been able to classically condition forearm muscle responses to neutral tones.

**Overreactivity in Response to an Innocuous Stimulus:** They feel that this is part of a stereotyped response to a variety of stimuli which causes the same maximal response in the musculoskeletal system regardless of the intensity of the stimulus. A corollary to this would be that the musculoskeletal system would be more reactive than other systems. This would lead to over-utilization of the responding group of muscles and, then to pain from over-utilization. They showed that, in fact, the low back muscles of low back pain subjects are far more reactive to stressors such as mild heat or touch pain and mental stresses (math, images, etc.) than are either healthy controls or people with other types of chronic pain. Interestingly, the back pain patients do not have higher resting levels of EMG than the other groups. They also found that the back pain patients' back muscles reacted more than their biceps. These people's heart rates were far less responsive to mental stressors than the other groups'. Jensen, Rasmussen, Pedersen, Olesen (1993) and Bendtsen, Jensen, & Olesen (1996) found that when muscles are pressed against with increasing force, relatively tender muscles hurt with much less force than non-tender ones.
Jensen was involved with both studies. He concluded that the abnormal pain response of muscles with histories of pain is sufficient to account for muscle tension related headaches and most other muscle related pain.

Susan Middaugh and her team (e.g. Middaugh et al 1994, 1995, 1998, 1999) have conducted numerous studies relating posture to development of muscle tension related pain. For example, twenty pain free subjects sat at a keyboard and typed with either relatively proper posture or thirty degrees of forward shoulder flexion for twenty minutes. Trapezius EMG began about twice as high with incorrect posture as with normal posture and continued rising throughout the session while remaining constantly low for the correct posture period. The muscle quickly fatigued and discomfort set in. A group of 35 consecutive headache patients was shown to have an average of 16 degrees of forward head posture with a variance of 60 to 128 percent above the values considered sufficient to cause pain. They found that shoulder muscle tension when sitting quietly was relatively elevated among 65% of cervical pain patients, 57% of headache patients, and 25% of normals. However, when they shrugged or abducted the shoulder, 95 to 94% of the cervical and headache patients had abnormal levels while only 9 to 19 percent of the normals had abnormal levels.

Thus, the evidence is gradually growing that (1) there is, indeed, a strong relationship between posture related pain and abnormal levels of muscle tension and (2) correction of abnormal muscle tension results in reduction of the pain.

**Interventions:** The use of psychophysiological treatments for chronic musculoskeletal pain is one of the staples of clinical psychophysiology. The basic concept is that much of the pain people experience is caused by muscles being kept too tense for too long. They may be kept that way due to guarding (preventing movement due to pain from some other source), poor posture, stress reactions, incorrect sequencing of muscles during movement etc.

Most people who use biofeedback and other psychophysiological interventions for chronic back pain mix them relatively randomly with every other intervention available at their sites (e.g., Roberts, Sternbach, & Polich, 1993) and it is frequently impossible to determine whether the psychophysiological intervention had any effect or even just how it was applied. There is no evidence that psychophysiological interventions play an important role in any effects
the multi-modality programs may produce or that they are applied well enough for long enough to produce any effects they might be capable of.

Arena and Miller (2003), Flor and Turk (1989) and Sherman and Arena (1992) have reviewed the literature on the use of psychophysiological techniques for treatment of low back pain. Sherman and Arena’s (1992) review of twenty-nine clinical studies as well as the author’s own review of several more recent studies indicates that biofeedback is likely to help at least some people with muscle tension related low back pain to some extent. Almost all of the studies have serious flaws in design including:

- Only 13 studies have sample sizes over nine.
- Only a few specify the diagnostic methodology.
- Only 10 have any controls (e.g. waiting lists, etc.)
- Only a few factored changes in medication into their results.
- Only three had follow-ups of six months or more.
- Only several had subjects keep pain diaries or had multiple objective outcome measures.

Gevirtz, Hubbard, & Harpin (1996) also reviewed the literature and found that psychophysiological treatments for chronic low back pain are generally efficacious although the mechanisms through which treatments work are poorly understood.

There have been no large single group or multi-practitioner studies of applied psychophysiological interventions for back pain similar to those performed with headache patients.

Flor's group (e.g., Flor and Birbaumer, 1994) has done a succession of studies with chronic back pain patients. They included patients with all diagnoses of chronic low back pain. They found an overall improvement rate of about 65 percent at short-term follow-up relative to about a one third improvement rate for placebo controls and no improvement for non-treatment controls. The improvement was sustained on two-year follow-up and resulted in a corresponding decrease in use of the health care system (Flor and Birbaumer, 1994). Patients participated in either hour long biofeedback sessions during which they had to decrease muscle tension while in uncomfortable positions and while imagining stressful events. The group performed similar studies comparing the efficacy of biofeedback to cognitive-behavioral and standard medical
treatments with similar results. The duration of pain was significantly correlated with extent of success in this series of studies. Several hundred patients participated in this series of studies so the results are very unlikely to be random.

The same group (Flor, Hagg, & Turk, 1986) did a small study in which they used EMG biofeedback with chronic rheumatic back pain patients. A 2.5 year follow-up of 22 of the original 24 participants showed that those treated with biofeedback maintained gains more than “pseudotherapy” and standard therapy alone.

Newton-John, Spence, & Shotte (1995), as quoted by Yucha and Gilbert (2004), “compared genitive therapy with EMG biofeedback in chronic back patients and obtained similar beneficial effects with both as compared to a wait-list control group. Effects persisted at a six-month follow-up”. Also as noted by Yucha and Gilbert (2004), “Vlaeyen and colleagues (1995) studies response to EMG biofeedback training in 71 chronic back-pain patients in comparison with a cognitive-training group. The groups had comparable positive outcomes as compared to wait-list controls and an operant-conditioning only treatment.

Susan Middaugh and her team (e.g., Middaugh, Kee & Nicholson, 1994) have conducted numerous studies in which abnormal muscle tension was usually assessed as being due to incorrect posture. Correction of the postural problem resulted in alleviation or elimination of the pain. She emphasizes the need for patients to be trained to minimize tension in painful muscles during normal activities involving the muscle and keeping the muscle quiet during activities which do not involve the muscle. This means that tension in the painful muscles is shown to the patients (“fed back”) while they are performing a variety of activities found to be associated with pain. Patients are shown the differences in muscle tension when posture is correct and incorrect. Neblett, Gatchell, and Mayer (2003) have published a series of EMG feedback assisted exercises which are useful for helping patients stretch tight muscles. The article includes photos illustrating how the exercises should be performed. However, caution should be used in recommending such exercises if the therapist is not trained in providing them.

Barbara Headley (1990, 1993), Eric Fogel (1995), and Glenn Kasman (1990) have developed specific protocols for physical therapists to use which incorporate surface EMG into pain evaluation and treatment (including biofeedback) programs. Unfortunately, none conducted
nor report large studies which verify their logical recommendations. Thus, numerous case reports and clinical lore form the basis for conducting these evaluations and treatments. They are very similar to Middaugh's work in that they involve using surface EMG to assess the functioning of a muscle or muscle group while normal activities are attempted. EMG biofeedback is incorporated into standard physical therapy to give the therapist and patient an excellent idea of how the muscle is performing. This permits rapid change of activity to desired levels.

**Specific Protocols:** Most people applying the techniques involved with retraining muscles to tense correctly (e.g., Ettare and Ettare 1990) emphasize that this is a behavioral conditioning process more similar to learning to ride a bicycle than to learning to play chess. Development of unconscious control through repetition of specific small tasks taken in steps is emphasized. Usually biofeedback devices are used with their thresholds set so that it is easy to reach an immediate goal. When that is reached, the threshold is reset so the next can be strived for and met. Thus, muscle tension is gradually shaped to the correct pattern.

While it is certainly true that large studies with long follow-ups confirming the effectiveness of these techniques have not been performed, the problems with muscle activity are so apparent during multichannel recordings of bending and rising that viewers have little doubt that an actual problem exists. When the levels of activity are altered to “normal” through the use of biofeedback, the difference is very obvious and patients report rapid resolution of the problem. Figure Three illustrates a typical example of changes in symmetry of the paraspinal muscles from a pre-treatment session through mid treatment. Changes from great asymmetry to relative symmetry are usually accompanied by corresponding decreases in pain.
Figure Three. EMG recordings of bilateral paraspinal muscle activity during a symmetrical activity (simulation). Both muscles should follow approximately the same pattern of tensing and relaxing during a motion and should reach about the same levels of tension. The solid line is the left paraspinal and the dotted line is the right paraspinal. The figure shows a patient attempting to tense both sets of muscles, hold the tension, and relax again. The patterns are obviously less symmetrical before than after training.

It is important to emphasize teaching patients to instantly shut off the paraspinal muscles after straightening up following a bend and rise cycle. If the trapezius is involved, teach patients to instantly shut them off after a shrug. Most patients with low back pain have far more tension in their paraspinals than is normal – even given the incredible range of “normal” discussed earlier. For these patients, I use virtually exactly the same protocol as described for headaches except that tension in both the left and right paraspinals and, as appropriate, the trapezius, is fed back. Patients are given the same tension awareness / relaxation exercise and are told to practice it the same way as are headache patients. They are taught to become very aware of when they are tensing their back muscles inappropriately at home and then in the work environment.

During the first half of a typical biofeedback session have patients begin in a standing position. First they work on relaxing their muscle to normal levels using shaping techniques as necessary. Then they tense the lower back for about two seconds and then relax for about five seconds. Have the patient repeat this cycle at least ten times while we both watch the monitor and work to correct abnormalities. Remember that most patients with low back pain can’t tell
how tense their muscles are so you are training them to recognize how tense they actually are at various levels of tension. This is the calibration exercise discussed earlier. For the last half of the session, have the patient bend forward 30 degrees and then stand back up slowly. The key is to get them to keep the signals of the two EMG channels within about fifteen percent of symmetrical (about the normal amount of left – right variability) and to relax quickly when they stand up.

Physical therapists with extensive experience incorporating biofeedback into back pain interventions such as Glenn Kasman (1998), Susan Middaugh (2003), Randy Neblett (2002, 2004), Steve Wolf (1998), and many others have developed detailed protocols for treating musculoskeletal back pain. The protocols usually center around (1) correcting posture – especially during work, (2) correcting incorrect motions, and (3) strengthening weak muscles. These form the basis for the author’s treatments as well. Always attempt to simulate the environment in which the back pain occurs. Thus, for people who spend a great deal of time working at computers, simulate the computer work station and do both an ergonomic and muscle tension evaluation of their position and work habits. The lack of micro-breaks during typing and similar work is very evident when watching the recording.

A crucial part of training is to incorporate the “five percent” rule into the biofeedback regime. It is based on Susan Middaugh’s philosophy that limbs kept only five degrees away from proper posture (e.g. arms slightly forward of vertical while using a keyboard), muscles kept only five percent tenser than necessary while working (e.g. shoulders tense while typing), and (from Glaros’s work) muscles kept minimally tense only five percent longer than necessary (e.g. after the task is completed) can result in severe pain which quickly becomes chronic. Thus, it is important to insure that any problems of this nature are noted, the patient is trained to become aware of them, and to correct them immediately. When dealing with people who do manual labor, I am especially careful to train them to be very aware of (1) when muscles are inappropriately tense during the task and (2) when muscles remain inappropriately tense after the task. This training virtually always requires training patients in muscle tension awareness and relaxation skills.
Correcting Concurrent Problems:
Posture. Correcting postural problems is as important as correcting the static and motion problems described above so patients must be taught to be aware of and to correct any such problems which became evident during the assessment. See the appendices for exercises.

Improper Back Utilization and Weakness. Very often patients use their back incorrectly at the work place, sit incorrectly, or simply have muscles too weak to perform the required tasks. Evaluation of these problems is normally performed by physical and occupational therapists trained in ergonomics. They frequently perform biofeedback interventions in the work place or work with therapists trained to perform biofeedback to correct muscle use problems. They tend to prescribe a very wide variety of muscle strengthening exercises as discussed earlier.

Treatments for Piriformis Syndrome and Trigger Points. If piriformis syndrome or trigger points are present, they have to be treated either before or concurrently with the psychophysiological intervention or the odds of making real progress are minimal.

3. Non-Cardiac Chest Pain

Gevirtz and his team (DeGuire, Gevirtz, Hawkinson, & Dixon,1996; Gevirtz, 2001; Moynihan & Gevirtz 2001) have shown that there is a solid relationship between anxiety and non-cardiac related chest pain. They have also shown that abnormal patterns of respiration, which are well known to lead to feelings of anxiety due to changes in concentration of carbon dioxide, also result in non-cardiac chest pain. Their review of the literature indicates that between 51 and 90% of non-cardiac related chest pain is associated with hyperventilation. Retraining breathing patterns results in long term (at least three years) control of stress-related cardiac pain symptoms and hyperventilation-related symptoms such as anxiety. DeGuire, et al. evaluated:

…the long-term effects of paced diaphragmatic breathing on subjects who reported functional cardiac symptoms and who also demonstrated associated signs of hyperventilation syndrome. Subjects were a representative sample composed of 10 out of the original 41 subjects who had participated three years previously in a study designed to evaluate the short-term effects of breathing retraining on functional cardiac symptoms
and respiratory parameters (respiratory rate and end-tidal carbon dioxide). The results of this follow-up study indicate that breathing retraining had lasting effects on both respiratory parameters measured. Subjects evidenced significantly higher end-tidal carbon dioxide levels and lower respiratory rates when compared to pretreatment levels measured three years earlier. Subjects also continued to report a decrease in the frequency of functional cardiac symptoms when compared to pretreatment levels (1996). Their study shows that correction of abnormal breathing patterns relieves the chest pain or eliminates it all together without further intervention to correct an anxiety disorder. Thus, it is the sequelae of incorrect breathing which create both anxiety and chest pain for many patients – not an underlying anxiety disorder which results in incorrect breathing.

Potts, Lewin, Fox, and Johnstone used a combination of: …education, relaxation, breathing training, graded exposure to activity and exercise, and challenging automatic thoughts about heart disease to treat 60 patients who had continuing chest pain despite cardiological reassurance following haemodynamically normal angiography. The treatment was delivered in six sessions over eight weeks to groups of up to six patients. The patients kept daily records of chest pain episode frequency and nitrate use. Questionnaires were used to assess anxiety, depression and disability. Exercise tolerance was tested by treadmill electrocardiography, with capnographic assessment of hyperventilation. The results were compared with waiting-list controls. Treatment significantly reduced chest pain episodes (p < 0.01) from median 6.5 to 2.5 per week. There were significant improvements in anxiety and depression scores (p < 0.05), disability rating (p < 0.0001) and exercise tolerance (p < 0.05), and these were maintained at six month follow-up. Treatment reduced the prevalence of hyperventilation from 54% to 34% (p < 0.01) but not the prevalence of ECG-positive exercise tests. Patients continuing to attribute their pain to heart disease had poorer outcomes (1999).

There is now substantial evidence from studies by Gevirtz and others that psychophysiological approaches such as (1) respiration training (2) resonant frequency training (heart rate variability biofeedback), and (3) autogenic training should all produce at least some success. Not enough studies have been done to estimate success rates in relation to initial
severity, or to establish the duration of effectiveness. Autogenic training for treatment of angina pectoris is supported by one good controlled study with a four year follow-up (Laberke, 1952, as reviewed by Linden, 1994).

Del Pozo, Gevirtz, Scher, and Guarneri (2004) demonstrated that cardiorespiratory (heart rate variability) biofeedback effectively increased heart rate variability in patients with documented coronary artery disease (CAD). They used “patients with established CAD (n = 63; mean age 67 years) who were randomly assigned to conventional therapy or to 6 biofeedback sessions consisting of abdominal breath training, heart and respiratory physiologic feedback, and daily breathing practice. HRV was measured by the standard deviation of normal-to-normal QRS complexes (SDNN) at week 1 (pretreatment), week 6 (after treatment), and week 18 (follow-up). Baseline characteristics were similar for the treatment and control groups. The SDNN for the biofeedback and control groups did not differ at baseline or at week 6 but were significantly different at week 18. The biofeedback group showed a significant increase in SDNN from baseline to week 6 (P <.001) and to week 18 (P =.003). The control subjects had no change from baseline to week 6 (P =.214) and week 18 (P =.27).”

It is concluded that psychophysiological techniques can be applied with confidence to the amelioration of non-cardiac chest pain.
4. Pelvic Floor Pain Disorders Amenable To Psychophysiological Interventions

There is moderate evidence supporting the effectiveness of psychophysiological interventions for the following pelvic floor related pain disorders:

1. PMS
2. Dysmenorrhea
3. Vulvar vestibulitis
4. Constipation related pain

Virtually all of the articles identified in a recent literature search are relatively small clinical studies and have short follow-up periods so little is known about the long term impact of biofeedback on work related deficits related to either PMS or dysmenorrhea. Dietvorst and Osborne (as quoted in Sherman, 2004) published a case study in 1978 in which they used temperature biofeedback and autogenic relaxation training to successfully treat a woman with chronic primary dysmenorrhea. Breckenridge, Gates, Hall, and Evans (1983) gave 12 weekly EMG feedback sessions to eight young women with primary dysmenorrhea. They showed a significant decrease in severity of dysmenorrhea symptom scores on the Menstrual Symptom Questionnaire. Balick, Elfner, May, and Moore (1982) did a similar study with the addition of temperature feedback given to nine dysmenorrheic women (aged 20 - 33) and found similar results upon six month follow-up. Bennink, Hulst, and Benthem (1982) did a controlled study in which subjects who received only relaxation training or a no treatment control did not change while those receiving biofeedback did. Hart, Mathisen, and Prater (1981) used a self-controlled design in which two month baseline and follow-up periods were compared for eleven subjects with primary dysmenorrhea. They used both GSR and EMG feedback and found a significant reduction in symptoms upon follow-up. Mathew, Claghorn, Largen, and Dobbins (1979) treated twelve women with PMS with temperature biofeedback and found changes on the Menstrual Distress Questionnaire. The author’s team (Hamblen, Sherman, and Powell 1996) completed an open study in which thirty female soldiers with mixed PMS and dysmenorrhea were treated with a combination of progressive muscle relaxation exercises, frontal EMG biofeedback, and fingertip temperature biofeedback. Each kept a one month log of symptom severity and work impact before and after the standardized eight week treatment. Reports to the therapist indicated
that most showed dramatic improvements but (a) only five subjects actually handed in a fully completed post treatment long and (b) the long term follow-up was not funded so it is not known whether the effects were maintained.

The use of psychophysiological interventions for amelioration of pelvic floor muscle related pain has become a staple of clinical practice. The author has trained numerous patients with considerable success. However, the author has not been able to find any studies actually demonstrating their effectiveness. This lack of evidence is not to be confused with the reasonably strong evidence supporting the use of biofeedback for strengthening and reducing both spasms and instability in the pelvic floor as part of treatments for incontinence. The key elements in any of the treatment approaches are: (a) perform a surface EMG evaluation to determine whether the muscles are inappropriately tense or relaxed and whether accessory muscles (such as those in the abdomen) are tensing at the wrong time, (b) teach subjects to recognize when they are inappropriately tense or relaxed, and (c) teach the subjects to tense or relax appropriately. This obviously can not be done without a very solid understanding of what the muscles are supposed to be doing and how tense they are supposed to be, at each point in the sequence leading to urination. Tries and Eisman's review (1995) provides the best information for this area.

Glazer, Rodke, Swencionis, Hertz, and Young (1995) studied 33 women having pain due to vulvar vestibulitis syndrome in which they gave SEMG biofeedback and relaxation training from the pelvic floor twice per week for 16 weeks to correct muscular instability, irritability, and weakness. After training, pelvic floor muscle contractions increased by 95.4%, resting tension levels decreased by 68%, and instability at rest decreased by 62%. Of great importance, pain decreased by 83% from baseline levels.

Turnbull and Ritvo (1992) used biofeedback and relaxation exercises to treat painful constipation among five women. Pain decreased significantly along with the other symptoms.

Glazer’s approach to treatment includes biofeedback assisted exercises to stabilize the pelvic floor. He has patients perform 60 cycles of contracting the floor muscles and holding for 10 seconds then relaxing for ten seconds. The session takes about 20 minutes. Reducing fatigue is accomplished by holding tension for 10 seconds while reducing variability. This permits reduction of resting tension to 0.5 to 1 microvolt. The difference between normal readings and those made from a patient with vestibulitis is illustrated in Figure Four. White, Jantos, and
Glazer (1997) have found similar patterns and published good illustrations of what can be expected before and after therapy.

**Figure Four.** Differences between normal pelvic floor muscle tension recordings and those typical of patients with vestibulitis. *Simulation based on a compilation of our data and reading White et al’s (1997) work.*

![Graph showing differences between normal and abnormal pelvic floor muscle tension recordings.](image-url)

- Normal baseline and pattern of tensing
- Elevated, unstable baseline and ineffective, spasmodic pattern of tensing shown by patients with vulvar vestibulitis
EFFICACY RATINGS FOR PSYCHOPHYSIOLOGICAL ASSESSMENT AND BIOFEEDBACK OF CHRONIC PAIN PROBLEMS

Rating Criteria:

The Association for Applied Psychophysiology has developed the following criteria for setting the level of evidence for efficacy (Moss and Gunkelman 2002, LaVaque et al 2002):

Level 1: Not empirically supported: Supported only by anecdotal reports and/or case studies in non-peer reviewed venues.

Level 2: Possibly Efficacious: At least one study of sufficient statistical power with well identified outcome measures, but lacking randomized assignment to a control condition internal to the study.

Level 3: Probably Efficacious: Multiple observational studies, clinical studies, wait list controlled studies, and within subject and intrasubject replication studies that demonstrate efficacy.

Level 4: Efficacious:

a.) In a comparison with a no-treatment control group, alternative treatment group, or sham (placebo) control utilizing randomized assignment, the investigational treatment is shown to be statistically significantly superior to the control condition or the investigational treatment is equivalent to a treatment of established efficacy in a study with sufficient power to detect moderate differences, and

b.) The studies have been conducted with a population treated for a specific problem, for whom inclusion criteria are delineated in a reliable, operationally defined manner, and

c.) The study used valid and clearly specified outcome measures related to the problem being treated and

d.) The data are subjected to appropriate data analysis, and
The diagnostic and treatment variables and procedures are clearly defined in a manner that permits replication of the study by independent researchers, and

The superiority or equivalence of the investigational treatment have been shown in at least two independent research settings.

Level 5: Efficacious and specific: The investigational treatment has been shown to be statistically superior to credible sham therapy, pill, or alternative bona fide treatment in at least two independent research settings.

Ratings of the efficacy of biofeedback based interventions for disorders whose main symptom of interest is chronic pain:

Chronic pain includes too broad a range of disorders to assign a single efficacy rating. Table 1 contains ratings for each chronic pain disorder along with citations to studies supporting the rating.

Table 1. Efficacy Ratings of Chronic Pain Disorders

Efficacious and specific (Fifth level):


(b) Tension headache in both adults and children (Review by Blanchard 1992)

Efficacious (Fourth Level):

(a) Muscle related orofacial pain (Review by Glaros & Lausten, 2002)

(d) Irritable bowel syndrome (Differing reviews, by Blanchard, 1993, and by Humphries & Gevirtz, 2000)

(e) Anxiety related to incorrect breathing patterns causing non-cardiac chest pain (Reviews by Gevirtz, 2001, DeGuire, Gevirtz, Hawkinson, & Dixon, 1996)
(f) Posture related pain problems such as forward head thrust (Review by Middaugh, 1994)

**Probably efficacious (Third level):**

(a) Muscle related low back pain (Reviews by Flor, et al., 1993, 1994)
(b) Cramping and burning phantom limb pain (Review by Sherman, Devore, Jones, Katz, & Marbach, 1996, Flor, 2002)
(c) PMS and Dysmenorrhea (Breckenridge, 1983)
(d) Pain from spastic muscles and muscle spasms (Kasman, 1998)
(e) Subluxation of the Patella and patelofemoral pain (Ingersoll & Knight, 1991)
(f) Magnification of pain by stress & anxiety (Yucha and Gilbert, 2004)
(g) Pelvic floor pain syndromes (Tries & Eisman, 1995, Glazer, Rodke, Swencionis, Hertz, & Young, 1995, Yucha and Gilbert, 2004)

**Possibly Efficacious (Second level):**

(b) Myofascial pain syndrome / trigger point related pain (reviews by Headley, 1991, and Gevirtz, 1995)
(c) Raynaud's syndrome (Review by Freedman, 1991)
(d) Repetitive strain injury (study by Moore & Weisner, 1996)
(e) Fibromyalgia (Yucha and Gilbert, 2004)

**Not empirically supported (First level of evidence):**

(a) Pain and spasticity due to not taking microbreaks among sign language translators, musicians, factory workers, computer workers, etc.
(b) Biofeedback for reflex sympathetic dystrophy.
CONCLUSION

Psychophysiological assessments and biofeedback based interventions for disorders whose main symptom of interest is chronic pain can be highly efficacious for selected disorders. There is a dearth of controlled studies in this area so the supporting evidence is not as strong as it might be. However, the evidence from formal studies shows that efficacy ranges from efficacious (e.g., treatment of migraine and tension headaches) to possibly efficacious and not empirically supported. There can be little doubt that psychophysiological measurements form a valuable part of the assessment process and that biofeedback based interventions should be given a trial for most chronic pain disorders.

REFERENCES


Del Pozo, J., Gevirtz, R., Scher, B., Guarneri, E. (2004). Biofeedback treatment increases heart rate variability in patients with known coronary artery disease. American Heart Journal, 147, E11. (This is an on-line journal which does not use page numbers.)


