Orientation for UW Medical Students
Visiting Bastyr University’s
Integrated Pain Treatment Shifts

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Welcome to the Bastyr Center for Natural Health!

• We are glad to have you observe on our Integrated Pain Management Shift
• The following slides will provide you with some logistical information about the clinic and also some basic information about the disciplines and modalities used on our pain shift
• Finally, you will find several recommended articles for reading
• We hope you enjoy and learn from your experience here
BASTYR CENTER FOR NATURAL HEALTH
3670 Stone Way N.
Seattle, WA 98103

Finding Us
The clinic is located on the east side of Stone Way south of 38th St.

Clinic Parking Facts:
All parking garage parking spots are reserved for Bastyr clinic patients.
Please do not park in the parking garage.
Two hour limit on street parking is in effect on most of the area surrounding the clinic. This means that your car must be moved to another street entirely every 2 hours. There is all day parking available in the surrounding areas 4-5 blocks out.
SHIFT LOGISTICS

CHECK-IN
Please check in at the 2nd Floor reception desk. You will be asked to sign a confidentiality form and will be given a visitor’s badge. The provider/s will be paged and you will be escorted to the preview/review room.

SHIFT FORMAT
Shifts are 4 hours – ½ hour preview, 3 hours of patient visits and ½ hour review.

DRESS
Please wear professional dress.

QUESTIONS
Please direct logistical questions to Clinical Faculty Services:
-Dana Seaman, S250, 206-834-4119, dseaman@bastyr.edu
-Benita Baird, S252, 206-834-4139, bbaird@bastyr.edu
Integrated Pain Management/Physical Medicine

Dr. Cristopher Bosted, ND
Adjunct Faculty
Supervisor of Physical Medicine
Bastyr Center for Natural Health
Introduction to Physical Medicine

- Evaluation, diagnosis and non-operative treatment of acute and chronic inflammatory, musculoskeletal and neurological disorders
- Preventative care
- Tailored to individual needs
Theory of Physical Medicine

• Body
  – Pain as caused by structural issues
    • Osseous vs. muscular vs. neurological vs. fascia or combinations of these.
    • Release restrictions to free the physical body

• Mind
  – Pain as caused by suffering
    • Stress from trauma, job, family, finances, chronic pain
    • Chronic pain leads to chronic depression and anxiety
    • Help patient find techniques for coping
Therapeutic Modalities

• Water
  – Hydrotherapy - application of hot/cold, hyperthermic baths with peat additive
  – Colonic Hydrotherapy

• Electricity
  – E-stim, Interferential Therapy, MMES, TENS

• Wave therapy
  – Ultra sound, Low Level Laser Therapy, Diathermy

• Manual
  – Craniosacral, massage techniques, visceral manipulation
Therapeutic Modalities cont.

• Mechanical
  – Osseous manipulation
  – Kinesiotape
  – Stretching and exercise techniques

• Counseling

• Nutrition
  – Dietary changes, nutriceutical support

• Botanical

• Homeopathy
Resources

• Craniosacral
  – http://www.craniosacral.co.uk/research
  – http://www.upledger.com/content.asp?id=76&mid=2
Clinical Biofeedback & MindBody Medicine

Brad S Lichtenstein, ND BCB
Associate
Clinical Professor
blickenstein@bastyr.edu

206-295-9978 cell
"STRESS"

THE CONFUSION CREATED WHEN ONE'S MIND OVERRIDES THE BODY'S BASIC DESIRE TO CHoke THE LIVING DAYLIGHTS OUT OF SOMEBODY WHO DESPERATELY NEEDS IT!
Naturopathic Therapeutic Order

- Cultivate Conditions for Health/Remove Obstacles to Cure
  - Stimulate the *Vis Medicatrix Naturae*
    - Tonify Weakened Systems
    - Correct Structural Integrity
  - Address pathology: Natural Substances
- Address pathology: Pharmacologic or Synthetic Substances
- Suppress or Surgically Remove Pathology

Zeff J.L. 1997; Snider & Zeff 1998; Zeff, Snider
Principles of Naturopathic Medicine

• Vis Medicatrix Naturae – The Healing Power of Nature
• Primum Non Nocere – First Do No Harm
• Tolle Causum – Treat the Cause
• Tolle Totum – Treat the Whole
• Docere – Doctor as Teacher
• Preventare - Prevention
Naturopathic Model of Healing

Normal Health

Disturbing Factor  

Discharge Process

Disturbance of Function

Reaction

(fever, inflammation, etc.)

Chronic Reaction

Degeneration

Definitions of Biofeedback

• Use of instrumentation to monitor, amplify and feedback information on voluntary and involuntary physiological response so that a patient can learn to regulate these responses. Form of psychophysiological self-regulation. When used to control brain activity, called neurofeedback.

• Process of recording physiological signals (such as muscle tension or brain waves) and displaying them to the person being recorded in real time as they are being recorded. This information is used to help patient learn to change physiology.

  – Association of Applied Psychophysiology and Biofeedback
Typical Systems Measured

• Breathing - Respiration Biofeedback
• Heart Rate & Heart Rate Variability (HRV) Biofeedback
• Muscle Tension - sEMG (surface electromyography)
• Sweat Response - GSR (galvanic skin response)
• Temperature – thermal biofeedback
• Brain Waves - EEG (electroencephalography)
Definitions of Mindbody Medicine

• Definition of Scope of Field (NCCAM)
  o “intervention strategies believed to promote health; relaxation, hypnosis, visual imagery, meditation, yoga, biofeedback, tai chi, qi gong, cognitive-behavioral therapies, group support, autogenic training, and spirituality”
  o Illness - opportunity for personal growth and transformation
  o Provider/Practitioner - catalysts and guides
Overall Goal of Biofeedback/Mindbody Medicine

To discover new ways of orienting and moving through the world

1. Learn it is safe to have feelings and sensations
2. Recognize that bodily processes are constantly changing (impermanent)
3. Cultivate capacity for introspection and interoception (medial prefrontal cortex)
4. Mobilize (unfreeze) and rediscover physical impulses
5. Reorient
Direct Aims of Biofeedback/Mindbody Medicine

1. **Awareness** – interoception and introspection - discern psycho-physiological sensations and changes (*what is happening; what does it feel like*)

2. **Control/Modulate** – alter or change psycho-physiological process at will

3. **Generalize** – control changes at any time – make it applicable to other parts of life
Related Techniques

- Yoga and Therapeutic Exercise
- Breathing and Breath Retraining
- Progressive Muscle Relaxation (PMR)
- Autogenic Therapy/Hypnotherapy
- Guided Visualization/Imagery
- Mindfulness and Meditation
Classification of Meditation

1. **Mantra meditation** (TM, relaxation response, and clinically standardized meditation)

2. **Mindfulness meditation** (Vipassana, Zen Buddhist meditation, MBSR, and MBCT)

3. **Yoga** (Based on Indian Yogic tradition of Patanjali, incorporates various techniques like asanas, pranayama, meditation, etc.)

4. **Tai Chi** (incorporates slow rhythmic movements emphasizing force and complete relaxation)

5. **Qi Gong** (practice combining breathing with various postures, bodily movements, and meditation)

## Indications and Contraindications

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<thead>
<tr>
<th>Best</th>
<th>Good</th>
<th>Maybe</th>
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<tr>
<td>Tension – type headaches</td>
<td>Insomnia, psychophysiological</td>
<td>Writer’s cramp; occupational cramps of musicians</td>
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<tr>
<td>Migraine headaches</td>
<td>Anxiety disorders; Generalized anxiety disorders; phobias; PTSD</td>
<td>Other dystonias (torticollis)</td>
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<td>Nocturnal enuresis</td>
<td>Attention deficit/hyperactivity disorders</td>
<td>Plepharospasm</td>
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<td>Fecal incontinence</td>
<td>Epilepsy</td>
<td>Dermatological disorders</td>
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<td>Urinary incontinence</td>
<td>Nausea / vomiting</td>
<td>Diabetes</td>
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<td>Other pelvic floor disorders</td>
<td>Irritable bowel syndrome</td>
<td>Posture Training</td>
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<td>Essential Hypertension</td>
<td>Asthma</td>
<td>Menopausal hot flashes</td>
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<td>Phantom limb pain</td>
<td>TMJ Disorders and bruxism</td>
<td>Hyperfunctional dysphonia</td>
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<td></td>
<td>Tinnitus</td>
<td>Vasovagal or stress-induced syncope</td>
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<td>Raynaud’s disease and phenomenon</td>
<td>Essential tremors</td>
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<td></td>
<td>Chronic pain</td>
<td>Reflex sympathetic dystrophy/complex regional pain syndrome II</td>
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<td>Fibromyalgia</td>
<td>Psychoactive substance abuse/dependence</td>
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<td>Hyperventilation</td>
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Biofeedback-Assisted Relaxation Training for the Aging Chronic Pain Patient

Susan J. Middaugh, S. Elizabeth Woods, William G. Kee, R. Norman Harden, and John R. Peters
Medical University of South Carolina

The older segments of the U.S. population are expanding rapidly and account for a disproportionate amount of health care, including treatment for pain-related musculoskeletal disorders. In a prospective study with objective measures and one-year follow-up, Middaugh et al. (1988) found that older patients (55-78 yr; N = 17, 76% success) treated in a multidisciplinary chronic pain rehabilitation program enjoyed a success rate equal to that of younger patients (29-48 yr, N = 20, 70% success). The current study presents additional data on these two groups of patients to compare their ability to learn the physiological self-regulation skills taught in the biofeedback/relaxation component of the multimodal program. This component included progressive muscle relaxation training, diaphragmatic breathing instruction, and EMG biofeedback. Repeated measures ANOVA showed significant increases in digital skin temperature (peripheral vasodilation) and decreases in respiration rate both within and across training sessions (p values = .04 to .0001) with no differences between age groups (p > .05). EMG measures for the upper trapezius ms in patients with cervical pain showed similar deficits in muscle control at evaluation and similar improvements with biofeedback training for the two age groups. These findings indicate that older pain patients responded well to the biofeedback/relaxation training component of the multimodal pain program.

Descriptor Key Words: aging; biofeedback; chronic pain; relaxation training.

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2Address all correspondence to Susan J. Middaugh, Ph.D., Department of Physical Medicine and Rehabilitation, Medical University of South Carolina, 171 Ashley Avenue, Charleston, South Carolina 29425-2254.
The assessment and treatment of chronic musculoskeletal pain in the elderly is an area of growing clinical interest (Hunt, 1980; Middaugh, Levin, Kee, Barchiesi, & Roberts, 1988; Sorkin, Rudy, Hanlon, Turk, & Stieg, 1990; Sturgis, Dolce, & Dickerson, 1987). This interest is understandable since those aged 65 and older are the fastest growing segment of the United States' population. Furthermore, as of 1980 U.S. health care expenditures for the 11% of our population aged 65 and up accounted for 29% of total health care costs and an estimated 40% of physician practice time (Steinberg, 1984).

Musculoskeletal disorders are of special concern since they are the leading cause of chronic impairment in all age groups. However, the impact is greatest on the elderly. This diagnostic category accounts for 20% of Medicare hospitalization costs compared to an estimated 8% of hospital costs for all age groups (Ng, 1981; Kelsey, Pastides, & Bisbee, 1978). Pain is a concomitant of many, if not most, of these chronic musculoskeletal disorders, and it is well recognized that persistent pain can compound the disability produced by the primary diagnosis. Multidisciplinary chronic pain rehabilitation programs (CPRPs) are rapidly becoming the treatment of choice for chronic, benign, musculoskeletal pain (Barbarash, 1986; Ng, 1981). These programs incorporate both psychological and physical treatment modalities, and their clinical efficacy has been well established. Although success rates vary considerably, well-designed studies with clear, objective definitions of success and long-term follow-up have reported rates of 60% (Guck, 1985), 73% (Middaugh et al., 1988), and 75% (Painter, Seres, & Newman, 1980).

Despite the current interest in chronic pain rehabilitation in the older pain patient, there is surprisingly little information available in the literature on the effectiveness of multidisciplinary CPRPs for this population group. One problem is that most of the published clinical outcome studies report only the average age of their patients and do not report age range, much less age distribution, making it impossible to tell whether a given study — or a given treatment program — included older participants. However, it can be inferred from the typically low age averages that most studies include few, if any, elderly patients (e.g., mean age = 42.4 years, Guck, Skultety, Meilman, & Dowd, 1985). When age range is provided, it is even more apparent that older patients are seriously underrepresented. Even studies that include age as an outcome variable usually do not have good representation of patients in the upper end of the age range, and this limits the interpretation of positive or negative correlations between age and outcome variables. For example, a study by Aronoff and Evans (1982) reports a statistically significant negative correlation between age and treatment outcome in a series of 104 patients completing a 4-week program at a mul-
tidisciplinary pain center. Age range was not given, the mean age was a relatively low 45.2 years, and the correlation ($R = - .24$) accounted for only 6% of the variance in clinical outcome. Nevertheless, the authors conclude that “the significant negative correlations indicate a decline in success rate with older patients” and recommend that clinicians “screen their older patients more carefully.”

A second problem contributing to the current lack of published information on clinical outcome in elderly chronic pain patients is that such patients tend to be excluded from treatment programs. Older patients may be excluded directly by age, with upper limits set at age 55, 60, or 65 (Stark, 1983). More often, exclusion is indirect, through specification of age-related admission requirements such as vocational restoration as a treatment goal or absence of concurrent medical problems which would require modifications in standard treatment protocols (Gottlieb, Koller, & Alperson, 1982; Roberts & Reinhardt, 1980).

These exclusions — whether direct or indirect — seem to be based on little-tested assumptions that older patients will be more difficult to treat and will have a negative impact on program success rates. Many rehabilitation programs, including chronic pain rehabilitation programs, were initially developed to return disabled individuals to work, and there is often a strong bias against admitting older patients who have different goals or who may be medically more complicated. This orientation can limit the elderly individual’s access to rehabilitation services (Steinberg, 1984). This problem is well illustrated in the policy of the CPRP, which was described as follows: “The clinic will not take anyone older than 60 because it is believed that older patients have too many other health problems that may complicate the program” and because of the belief that admitting the elderly will negatively affect program success rates (Stark, 1983).

The CPRP at the Medical University of South Carolina has no age limitations, and our clinical impression has been that older patients perform well in the treatment program. In the first published, prospective study on clinical outcome of older chronic pain patients (Middaugh et al., 1988) we compared treatment outcome data on 17 older (55 to 78 years) and 20 younger patients (29 to 48 years) entering the CPRP. Treatment outcome was determined on the basis of eight quantitative measures of physical and psychological status obtained at an initial evaluation and at a follow-up contact, 6 to 12 months posttreatment. Comparison of the two age groups at the time of evaluation (pretreatment data) found two relevant differences: the older patients had nearly four times the rate of health care utilization ($p < .001$) and were taking almost twice the pain-related medication ($p < .057$) as their younger counterparts. Although marginally significant, the medication difference is clinically very relevant, since it is well recog-
nized that older patients metabolize medications more slowly and are more likely to have adverse drug reactions, particularly with polypharmacy (Kaiko, 1982). In addition, older patients were more likely to be female (76% vs. 45%) and were more often classified as markedly impaired (82% vs. 65%) prior to treatment. Yet both age groups improved significantly from evaluation to follow-up on most of the eight outcome measures and achieved equivalent success rates (76% for older vs. 70% for younger patients) using objective criteria. Of particular interest were the findings that the older group achieved a 93% reduction in health care utilization and a 64% reduction in pain-related medications. These data indicate that older patients benefit at least as much as their younger counterparts from a multidisciplinary CPRP.

In light of this initial study, a natural next step is to evaluate the response of older patients to the separate treatment components of the multimodal treatment format to determine if one or more of these components pose special difficulties for older individuals. Such information could point to modifications in treatment protocols which may be needed to make CPRPs optimally effective for older participants.

Biofeedback training, usually in combination with other relaxation therapies, is a common component of multimodal pain management programs; however, there are some indications in the literature that the biofeedback/relaxation component may be problematical for older patients. Questions have been raised regarding the effectiveness of biofeedback/relaxation therapies in treatment of older patients with headache diagnoses. Two retrospective studies (Blanchard, Andrasik, Evans, & Hillhouse, 1985; Diamond & Montrose, 1984) and a meta-analytic study (Holroyd & Penzien, 1986) have reported lower success rates for biofeedback/relaxation therapies with older headache patients, possibly because of the extended duration and refractory nature of the pain symptomatology and/or differences in psychophysiological responding which may limit or retard the treatment process (Arena, Blanchard, Adrasik, & Myers, 1983; Garwood, Engel, & Capriotti, 1982). However, two recent prospective studies (Arena, Hightower, & Chong, 1988; Kabela, Blanchard, Appelbaum, & Nicholson, 1989) report excellent success rates (70% and 63%, respectively) for older patients (aged 60-80) who achieved clinically significant reductions in headache activity and in medications. It is relevant that in both studies treatment protocols were tailored for a geriatric population by repetition and review of instructions to ensure comprehension and by simplification of some of the cognitive coping skills that were taught.

There is only one reference to biofeedback procedures for geriatric patients treated in a multimodal pain management setting for diagnoses other than headache. A paper by Kaplan and Kepes (1989) reported a
Table I. Sample Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Older</th>
<th>Younger</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>62.4</td>
<td>38.5</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
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</tr>
<tr>
<td>Males</td>
<td>4 (24%)</td>
<td>11 (55%)</td>
</tr>
<tr>
<td>Females</td>
<td>13 (76%)</td>
<td>9 (45%)</td>
</tr>
<tr>
<td>Duration of pain (months)</td>
<td>54.5</td>
<td>59.7</td>
</tr>
<tr>
<td>Area of pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back and neck</td>
<td>13 (76%)</td>
<td>17 (85%)</td>
</tr>
<tr>
<td>Other</td>
<td>4 (24%)</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Cause of pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td>9 (53%)</td>
<td>12 (60%)</td>
</tr>
<tr>
<td>Non-trauma</td>
<td>8 (47%)</td>
<td>8 (40%)</td>
</tr>
<tr>
<td>Number of surgeries</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Receiving financial</td>
<td></td>
<td></td>
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<tr>
<td>compensation</td>
<td>8 (47%)</td>
<td>9 (45%)</td>
</tr>
<tr>
<td>Educational level (years)</td>
<td>11.9</td>
<td>12.6</td>
</tr>
<tr>
<td>Number of sessions</td>
<td>8.5</td>
<td>8.3</td>
</tr>
<tr>
<td>Treatment mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inpatient</td>
<td>10 (59%)</td>
<td>7 (35%)</td>
</tr>
<tr>
<td>Outpatient</td>
<td>7 (41%)</td>
<td>13 (65%)</td>
</tr>
</tbody>
</table>

retrospective comparison of 206 patients under age 40 with 192 patients over age 70. Back pain was the most frequent diagnosis for both age groups. The abstract of the paper provides no specific outcome data but notes that overall outcome was "less favorable" in the elderly. Most interesting was their finding that the pain clinic treatment regimen for the older patients was more likely to include narcotic therapy and less likely to include TENS and biofeedback, which were considered "less suitable" for the elderly. In contrast, in our initial study (Middaugh et al., 1988) all patients in the multimodal CPRP received biofeedback/relaxation training, and this component was not noticeably more difficult for the older patients.

The present study specifically compares the performance of older and younger patients for the biofeedback/relaxation component. Since all patients participated in the full, multimodal CPRP, the present study does not attempt to analyze the contribution of biofeedback/relaxation to overall treatment outcome. Rather, the purpose of this study is to compare the ability of the older and younger patients to learn the physiological self-regulation skills taught in the biofeedback/relaxation treatment component. In particular, we were interested in obtaining objective data to clarify often cited assumptions that older patients (1) may be relatively more limited in psychophysiological responding, (2) may take longer to acquire an
equivalent level of skill, and (3) may be more refractory with respect to pain reports.

**METHOD**

**Subjects**

Participants in the study were 17 older patients (55 to 78 years) and 20 younger patients (29 to 48 years) who were treated in the MUSC multidisciplinary chronic pain rehabilitation program. Table I presents the demographic characteristics for the two age groups. Continuous variables (age, duration of pain, and number of surgeries) were analyzed by two-tailed t-tests. As planned, the groups were significantly different in age, \( p < 0.0001 \). Older and younger patients were similar in duration of pain and number of surgeries. Visual inspection of the dichotomous variable indicates that the groups were similar with respect to primary area of pain, cause of pain, financial compensation, educational level, and the total number of biofeedback-assisted relaxation training sessions attended. Older patients tended to be treated as inpatients somewhat more often than the younger patients (59% older vs. 35% younger), and the older group had a larger percentage of women than did the younger group (76% vs. 45%, \( p < .056 \) by Z-test of differences in proportions).

**Procedure**

Based on an initial evaluation by a physiatrist (a physician specializing in rehabilitation medicine), a clinical psychologist, and a BCIA certified physical therapist specializing in clinical biofeedback, patients were assigned to either the inpatient or the outpatient treatment program. Inpatients remained in the hospital for three to four weeks. Outpatients were seen two mornings (four hours) a week for eight weeks. Aside from the time difference (condensed vs. extended) and frequency of supervision (daily vs. twice weekly), treatment for inpatients and outpatients was closely equivalent, with the same clinical staff and clinical content.

The complete multimodal treatment program consisted of five major components including physical therapy, occupational therapy, behavioral psychology emphasizing cognitive skills and stress management, biofeedback/relaxation training, and medical management. Details on the entire treatment program and the overall clinical outcome for these 37 patients have been reported previously (Middaugh et al., 1988).
In the present study, additional data were obtained from the clinical records of these same patients in order to evaluate their performance on the biofeedback/relaxation component. This component consisted of 8 to 12 sessions of training in progressive muscle relaxation (PMR), diaphragmatic breathing, and electromyographic (EMG) biofeedback, with daily homework assignments.

Progressive muscle relaxation was initially taught using a 15-minute instructional tape with a gentle tense/relax sequence for major muscle groups. Patients were subsequently taught to relax without tensing and to incorporate diaphragmatic breathing into their relaxation practice. Progress in learning basic relaxation skills was assessed by monitoring digital skin temperature (°F, thermistor placed over the volar surface of the right index finger) and respiration rate (breaths per minute or BPM, counted for 1 minute by visual examination). Pre and post measures (Figures 1-4) were obtained from the first and the last treatment sessions in which PMR was performed. Within these two sessions, data were collected during the first and the last minute of the 15-minute PMR practice. Treatment goals were set at 93.5°F (94 to the nearest whole degree) or higher for hand temperature and 12 BPM or lower for respiration rate. These are relatively common minimum target values for clinical biofeedback training and are the values we routinely attempted to achieve in our clinical program. Room temperature was controlled by thermostat for the clinical area and was typically maintained within 68 to 72 degrees. In each session, patients sat quietly for at least 15 minutes prior to the start of the relaxation practice while homework was reviewed and electrodes were attached.

EMG biofeedback was used to teach improved voluntary control of muscle groups in the specific area of pain, typically the upper trapezius muscle for patients with cervical pain and the lumbar paraspinous muscles for patients with low back pain. The training activities varied with the patient and the muscle groups involved, but usually consisted of practicing muscle relaxation with EMG biofeedback while sitting, standing, walking, and performing a number of actual (e.g., writing) or simulated (e.g., driving) daily activities. Learned muscle control was assessed at the beginning and end of treatment by EMG recorded over the target muscles (a) during a baseline condition (quiet sitting for cervical pain, quiet standing for low back pain) and (b) during test movements which required a voluntary contraction of the target muscles in order to note the speed and extent of baseline recovery once the movement terminated. Training goals were set at 25 μV peak-to-peak or less during baseline and recovery of baseline EMG within 15 seconds.

EMG was recorded using a TECA dual-channel clinical EMG with an amplifier band-width of 20 to 1000 Hz with an oscilloscope and tape
Fig. 1. Digital skin temperature response to progressive muscle relaxation training in younger (N = 20) and older (N = 16) patients.

recorded. Beckman skin electrodes (.8 mm diameter silver/silver chloride) were placed (2 inches center-to-center) over the muscle belly after abrading and cleaning the skin to reduce resistance to 10 kΩ. EMG was quantified by noting whether it exceeded the 25-μV range indicator on the oscillograph screen. This peak-to-peak value for the raw signal approximates 3 μV when integrated and averaged. The EMG assessment and biofeedback training procedures are described in more detail elsewhere (Middaugh & Kee, 1987).

Finally, patients were asked to rate their pain on a 100-mm vertical visual analog scale to provide a measurement of subjective pain at initial evaluation and at discharge from the treatment program. Patients rated their present pain (Now), and were also asked to recall and rate their maximum (Max) and minimum (Min) pain for the previous week.

RESULTS

Figure 1 shows the digital skin temperature response to progressive muscle relaxation training in the older and younger patient groups for all but one older male, for whom consistent data were not available. A 2 (Age) × 2 (Session) × 2 (Pre-Post) ANOVA revealed no significant main effect for age and no significant interactions. There were significant increases in
digital skin temperature both within ($p < .0001$) and across ($p < .04$) sessions that were unrelated to age. The last session during which progressive muscle relaxation was performed with digital skin temperature monitoring was similar for older (mean = 7.56 sessions) and younger (mean = 7.35 sessions) patients.

Figure 2 shows the respiratory response during PMR for the two age groups, again with data for one older male missing. A $2 \times 2 \times 2$ ANOVA for respiration rate also showed no significant effect due to age. There were highly significant improvements for both age groups within ($p < .003$) and across ($p < .001$) sessions. There was also a significant three-way interaction ($p < .043$). Duncan's Multiple Range test for the difference between means with Bonferroni correction for multiple comparisons indicated that the changes for the two age groups were distributed differently across sessions. For the older group there were significant differences between Session 1 Pre vs. both Session 2 means ($p < .01$), while the significant differences for the younger group were Session 1 Pre vs. Session 2 Post ($p < .01$) and Session 1 Post vs. Session 2 Post ($p < .05$). Although three-way interactions are difficult to interpret, these differences, and the pattern of means illustrated in Figure 2, indicate that the older patients made a relatively greater proportion of their decreases earlier in the course of training and may have reached a floor by the final session with no further within-session change. For the younger patients, however, the within-session
Fig. 3. Digital skin temperature response to progressive muscle relaxation training in older (N = 13) and younger (N = 9) women and in younger men (N = 11).

decrease in the final session contributed to their overall change. The mean number of the last session of progressive muscle relaxation with
respiration data available was similar for the older (7.56) and the younger (7.40) groups.

Since a disproportionate number of older patients in this study were female, and gender effects may have obscured or interacted with age effects, digital skin temperature and respiratory rate were further analyzed by age and gender (see Figures 3 and 4). Since data were available for only 3 older males, they were excluded from these analyses. Younger men were compared with younger women to examine the effect of gender, holding age constant. A 2 (Sex) × 2 (Session) × 2 (Pre-Post) ANOVA revealed a significant main effect for sex ($p < .02$), indicating that males had consistently higher hand temperatures than females. Younger women were also compared with older women to examine the effect of age, holding gender constant, and there were no significant differences in hand temperature due to age ($p = .47$). The same comparisons were carried out for respiration rate. There was no difference in BPM due to gender for the younger patients ($p = .68$). The ANOVA comparing respiratory rates for older versus younger women yielded $p = 0.12$. Given the small numbers in each group, and the exploratory nature of this study, this finding is considered worth noting. It suggests that respiratory rate may be elevated in older women for this pain population.

Figure 5 illustrates the percentage of patients who achieved the specified training goals for the biofeedback/relaxation treatment component. Inspection of these data shows that a higher percentage of younger

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**Biofeedback Training Goals**

![Chart showing percentage of patients meeting goals for digital skin temperature, respiration rate, and relaxation of the upper trapezius muscles.](chart)

**Fig. 5.** Percentage of patients meeting the clinical goals for digital skin temperature, respiration rate, and relaxation of the upper trapezius muscles.
versus older patients met the training criteria for the three physiological variables: 70% vs. 56% for hand temperature; 75% vs. 63% for respiration rate; and 100% vs. 75% for EMG.

Since the muscles selected for EMG biofeedback training varied with diagnosis and site of pain symptoms, the EMG data are for the largest subgroup for whom consistent data were available, i.e., a total of 14 patients (6 younger and 8 older) with chronic cervical pain given EMG feedback training of the upper trapezius muscles bilaterally. 86% of the 14 (100% of younger and 75% of older) were able to consistently both (a) relax this muscle to criterion levels during sitting baseline and (b) recover the relaxed baseline rapidly after voluntary test contractions (three repetitions of shoulder shrug/relax) by the end of training. Prior to training, only 21% of the 14 (17% of younger and 25% of older) were able to meet this dual criterion. Comparisons of older versus younger patients are limited by the small numbers, but these findings indicate that patients (ages combined) were able to improve their ability to control muscles in the area of pain and also illustrate that the training tasks did not pose major difficulties for the older patients.

Finally, a 2 (Age) × 2 (Pre-Post) ANOVA was carried out for each of the 3 pain reports (Now, Max, and Min) obtained at evaluation and discharge for 14 of the older and 17 of the younger patients (see Figure 6). The analysis for present pain (Now) revealed no main effect for age.
(p = .88) or treatment (p = .11). There was, however, a significant treatment-by-age interaction (p < .05) due to significant decreases reported by the older group. Maximum reported pain decreased significantly for both age groups (p < .004) with no age effects. Finally, there were no significant changes in minimum pain reported by either age group.

**DISCUSSION**

Based on these data, it appears that the older patients responded appropriately and well to the biofeedback/relaxation component of a multidisciplinary pain program. Both older and younger patient groups made significant increases in digital skin temperature and decreases in respiration rate, both within and across an equal number of training sessions. Therefore, we can conclude that the older patients, as a group, readily acquired the expected physiological self-regulation skills.

The data in this study also raise some interesting questions about possible baseline differences between older and younger patients and potential interactions between age and gender. Such questions are relevant because clinically — as well as in this study — there are a disproportionate number of women in older age groups. With advancing age, women not only outnumber men in the general population, but older women have a higher incidence of diagnoses such as arthritis and osteoporosis that predispose them to musculoskeletal pain. When investigating age effects, therefore, it is often necessary to clarify the contribution of gender. In the present study, for example, older patients appear to have lower digital skin temperatures and higher respiration rates (Figures 1 and 2), but these differences were not found to be statistically significant with genders combined. Additional analyses, taking gender as well as age into account, indicated that what appeared to be a potential age difference in skin temperature was predominantly a gender difference (Figure 3), with significantly lower temperatures for women versus men in the younger group. The additional finding, that older women did not differ from younger women, is interesting since there are a number of reasons why advancing age could be expected to reduce baseline skin temperatures: lower metabolic rate, reduced physical activity and fitness, decreased circulation secondary to cardiovascular disease, and increased levels of plasma noradrenaline (Collins & Exton-Smith, 1983; Ziegler, Lake, & Kopin, 1976). Support for our findings is provided by two studies which compared psychophysiological responding for older and younger age groups in normal individuals (Arena et al.,
1983; Garwood, Engel, & Capriotti, 1982) and also found no differences in baseline skin temperatures due to age.

In contrast, for respiration rate the data suggest that age may possibly be a factor. Older women tended to have elevated respiration rates compared to their younger counterparts (Figure 4). This finding ($p = .12$) is very marginal but is mentioned because it may reflect such factors as limitations in ribcage excursion imposed by the degenerative changes in the thoracic spine which are quite common for older women, particularly in a chronic pain population.

These gender and age differences are, of course, limited by the low number of patients in each age/gender combination and by the relative lack of older men. However, our findings illustrate the need for further investigation in this area, particularly with patient populations rather than normal subjects only. For example, the issue of possible differences in baseline values is clinically relevant when using a training-to-criterion model with set clinical goals—a common clinical practice. Baseline differences between older and younger patients (or for men versus women) may lead to different success rates in terms of “goals met” when patients are responding equally well in terms of “extent of learned physiological change.” This is illustrated in Figure 5, in which older patients do not appear to be as successful as younger patients in terms of the percent meeting the preestablished clinical goals used in this study. Yet Figures 1 and 2 and the statistical analyses show that both age groups responded well to biofeedback/relaxation training with no statistically significant differences in the direction and extent of physiological change.

The EMG data for the subgroup of 14 patients (age and gender combined) who received EMG biofeedback training of the upper trapezius muscle demonstrate that a high proportion of patients, both older and younger, were able to acquire the basic muscle relaxation skills that were taught. No data were available for the more complex muscle control tasks (e.g., while walking) or for other muscle groups (low back paraspinous ms). Since muscle control is closely related to posture, and older patients are more likely to have fixed degenerative joint changes which negatively affect their posture, there may be limits to the degree of muscle relaxation and control that can be achieved. Again, clinical gains will need to be evaluated in terms of improvements in muscle control and not only the degree of control achieved at the end of training.

The pain report data are particularly encouraging and demonstrate that older chronic pain patients are not as fixed in their pain complaints as is often assumed. The older patients in this study achieved pain reductions equivalent to (Max) or greater than (Now) younger patients going through the same multidisciplinary program. The question might now be
Biofeedback Relaxation Training

asked, why did the older group do so well? The reductions in reported maximum pain ratings indicate that both age groups learned how to avoid major pain exacerbations. In the CPRP, patients are taught to identify precursors to major pain flare-ups and are taught prevention strategies; e.g., by learning to manage stress, to select and pace daily activities to avoid exceeding physical limits, and to perform these activities with correct posture and body mechanics. All patients, even those most severely physically disabled, are capable of making many helpful changes if they are compliant. Neither group reduced minimum pain. This is understandable since many of our patients report relatively low minimum pain levels prior to treatment — e.g., pain levels can be quite low for a day spent in bed — and it is both statistically and clinically difficult to reduce low values. For current pain (Now) there are several possible reasons why the older group reported greater improvements than the younger group. One possible reason is that patients are asked to progressively increase their activity levels over the course of treatment, and younger patients may have been pushed harder on the physical aspects of the program. A second reason is that older patients may have been more likely to report what the clinician wanted to hear. The pain ratings were obtained as a pencil and paper task during an initial and final psychology interview, and the psychologist was well known to the patients by discharge. In subsequent research we have used a 7-day pain diary to minimize possible reporting problems. A third reason is that older patients may have felt more free to acknowledge pain reductions. Even though many of the older patients were receiving compensation, they were above an acceptable early retirement age (55 yr), and there were relatively few return-to-work issues for this group.

The findings in this study also suggest a number of directions for further research. Certainly our results need to be replicated with increased numbers and under more formal, rigorous conditions. More information is needed on possible gender/age interactions and on response to EMG biofeedback training with additional muscles and training tasks. Further research is needed to investigate possible age-related ceiling or floor effects and how these may affect the clinical usefulness of physiological self-regulation procedures in our aging population. Such limits may be found, and some modifications of treatment protocols may be appropriate, as our studies include more of the oldest old, as medical status is taken into consideration, and as research is extended to other diagnoses and other physiological variables. Medication needs to be examined as a factor affecting physiological baselines and learned physiological change, particularly since older patients tend to be overmedicated compared to their younger counterparts (Middaugh et al., 1988). Finally, we are interested in examin-
ing why older patients perform as well as they do in a chronic pain rehabilitation program. One possibility, based on clinical observation, is that older patients may be more compliant. Since compliance is a major factor in outcome with self-regulation therapies, increased compliance may be sufficient to compensate for added difficulties the older individuals may have with the training tasks.

In conclusion, these findings indicate that biofeedback/relaxation training did not pose special problems for older chronic pain patients as compared to younger patients with similar diagnoses and duration of pain who were receiving treatment in the same multidisciplinary treatment program. Older patients (aged 55 to 78 yr), most of whom had chronic musculoskeletal pain diagnoses, (1) achieved equivalent direction and extent of physiological change, (2) learned the physiological self-regulation skills in a comparable number of training sessions, and (3) reported equivalent improvements in pain report for the chronic pain rehabilitation program as a whole. These findings, together with recent clinical outcome studies on headache patients (Kabela et al., 1989; Arena et al., 1988) provide objective evidence that biofeedback/relaxation therapies are appropriate as part of treatment programs for painful musculoskeletal disorders in our aging population.

REFERENCES


Biofeedback Relaxation Training


Biofeedback Applications

A Survey of Clinical Research

Sala Horowitz, Ph.D.

Behavioral approaches including biofeedback are part of the integrative medicine model that is increasingly being recognized and utilized by mainstream medicine. Biofeedback is being applied clinically and researched for an ever-widening range of disorders including chronic pain conditions, hypertension, incontinence, and attention deficit/hyperactivity disorder (ADHD).

Definition of Biofeedback

The Association for Applied Psychophysiology and Biofeedback (AAPB) defines biofeedback as a process that provides “real time information from psychophysiological recordings about the levels at which physiological systems are functioning.” (See box entitled Resources.)

The AAPB points out that, while computers or other electronic devices are typically used in biofeedback, such instrumentation is not required. For example, a mirror can function as a biofeedback device to provide external cues in gait retraining. The organization also notes that the feedback loop is complete only when the patient whose target function is being monitored attends to, and uses, the displayed information.

Historical Background

Biofeedback can be traced to experiments in the late 1950s and early 1960s showing that the autonomic nervous system is amenable to voluntary control via application of the principles of operant conditioning. The major biofeedback tool—the electroencephalograph (EEG)—was developed by a German psychiatrist, Hans Berger, M.D., in the 1920s. Dr. Berger believed that abnormalities measured by the EEG reflected clinical disorders.

This modality began filtering into clinical practice after Joseph Kamiya, Ph.D. (who was at the University of Chicago, Illinois, at the time) succeeded in training volunteers to recognize a specific brainwave pattern (namely, the alpha pattern). Dr. Kamiya’s landmark work, reported in a 1969 paper, demonstrated the standard phases of the feedback loop: (1) recording of a physiologic function of interest by a device (e.g., the EEG); (2) reinforcing patients by informing them each time the desired pattern of functioning occurs; and (3) patients achieving voluntary control of this activity.

The basic principles of electromyography (EMG), another widely used biofeedback measure, were discovered in the early 1960s.

Biofeedback Techniques

In EEG biofeedback, sensors placed on the scalp record the patient’s brainwaves, which are converted into amplified visual or auditory signals via a human–computer interface. Data amplitude is measured in microvolts. Based upon the treatment objective and plan, a protocol specifies the technical aspects of biofeedback training.

The EMG, a graphical representation recording neuronal activity in muscles anywhere in the body, provides feedback to patients about their levels of muscle tension and relaxation. EMG biofeedback records the electrical activity coming from the surface of the skin. EEG and EMG recordings can occur simultaneously.

Research Support for Clinical Applications

Attention Deficit/Hyperactivity Disorder

Neurofeedback, a subspecialty of EEG biofeedback, was developed by several practitioners, including Joel F. Lubar, B.S., Ph.D., a professor of psychology at the University of Tennessee, Knoxville. In neurofeedback, biofeedback is used to enhance attention and treat patients’ cognitive and behavioral problems as an alternative to conventional pharmacologic treatments.

Dr. Lubar, a past president of the AAPB, has conducted extensive research on treating pediatric and adult patients with ADHD since the mid-1970s. In 1992, Dr. Lubar and his colleagues reported that boys with ADHD differ significantly in their EEG patterns from boys without ADHD. The researchers compared EEG readings from 25 boys, ages 9–12, with ADHD to 27 age-matched controls. A neurofeedback protocol that Dr. Lubar developed has been used by many schools and health care organizations worldwide.

A review paper applying the efficacy guidelines developed by the AAPB (jointly with the International Society for Neuronal Regulation) determined EEG biofeedback to be “probably effica-
Cousin” for treating ADHD. Despite significant clinical improvement being reported in approximately 75 percent of the patients in each of the published studies, the reviewers called for additional randomized, controlled group studies.6

The Low Energy Neurofeedback System (LENS), a variant of neurofeedback using EEG biofeedback plus weak electromagnetic fields to stimulate brainwave activity, has also been applied in treating ADHD and other brain-function disorders.7

Canadian researchers recently studied the effect of neurofeedback on neural substrates of selective attention in children with ADHD. Functional magnetic resonance imaging (fMRI) studies of patients with ADHD had identified abnormal functioning of the anterior cingulate cortex (ACC) during tasks involving selective attention. Twenty (20) children with ADHD participated; 15 of these children were assigned to a training group. After 1 week of neurofeedback training, significant activation was shown in the right ACC only in the children in the training group when they performed a counting task.8

In a Chinese study of 60 children older than 6 who were diagnosed with ADHD, EEG biofeedback was 92 percent effective after 40 training sessions. Performance on an integrated visual and auditory continuous performance test was significantly improved whether patients had predominantly hyperactive, inattentive, or the combined type of the disorder.9

Chronic Pain Disorders

Migraine is one of the complex pain disorders for which biofeedback treatment has been discussed in the literature since the mid-1970s. New evidence from a large, prospective cohort of women indicates that treating migraine—at least in women diagnosed with migraine with aura—is particularly important because migraine is associated with an increased risk profile for cardiovascular disease.10

Biofeedback can help in the prevention or treatment of migraine by promoting diaphragmatic breathing and systematic relaxation. In a randomized study of 192 patients with migraine, resurgence of symptoms was significantly reduced at 1-year follow-up by training in EMG and temperature biofeedback compared with patients taking 80 mg per day of propranolol. Such an intergroup difference was not significant at 6 months.11

A recent systematic review of 19 controlled clinical trials (from databases up to June 2004), reporting the effects of nonpharmacologic prophylactic treatment in children with migraine, indicated that biofeedback in tandem with relaxation and/or cognitive behavioral treatment was more effective compared with wait-list controls.12

Biofeedback combined with cognitive behavioral skills training prevented the symptoms of patients at high risk for acute temporomandibular (TMD)-related pain from progressing to chronic...
TMD disorder. At 1 year, the patients in the early intervention group had significantly lower levels of self-reported jaw pain and depression than patients in the nonintervention group.13

A review of 30 studies of physical therapy modalities for treating TMD concluded that biofeedback may be more effective than placebo or occlusial splints.14

A preliminary study with 5 women patients suggested that thermal biofeedback is able to diminish pain associated with endometriosis.16

Biofeedback may contribute to reducing the risk of painful work-related musculoskeletal disorder development by providing information on exertion of the upper trapezius muscle during computer work.17

Behavioral therapies such as biofeedback have also been shown to be more effective than medications in pain management for hospice patients.18

Researchers at the Vanderbilt University School of Medicine, in Nashville, Tennessee, recommend that patients with complex regional pain syndrome be treated with a multi-disciplinary approach including relaxation training with biofeedback.19

Hypertension

A recent review of more than 100 randomized clinical trials of the efficacy of behavioral treatments for hypertension suggested that behavioral treatments reduce blood pressure to a modest degree compared with what occurs in patients in wait-lists or in other inactive control groups. Among biofeedback treatments, thermal and electrodermal activity feedback fared better than EMG or direct blood-pressure feedback.20

Biofeedback and other behavioral treatments for hypertension are particularly indicated in patients who are hypersensitive to stress and who have difficulty in tolerating or complying with antihypertensive drug regimens.21

A pedometer has been used as a “low-tech” biofeedback device for reducing coronary risk factors in an integrative program of exercise, weight management, and pharmacologic medications.22

Seizure Disorders

The treatment of epilepsy via conditioning of the sensorimotor EEG dates back more than 3 decades. Such neurobiofeedback-assisted learning of sensory motor rhythm production, representing an inhibitory state, results in an upregulation of excitation thresholds associated with reduced susceptibility to seizures. Independent laboratories have documented the clinical benefits of such a training protocol, especially for patients whose conditions are nonresponsive to standard anticonvulsant medications.23

Nonepileptic seizures of psychogenic origin in children have also proved amenable to biofeedback training. For example, a 13-year-old girl with such seizures experienced good therapeutic results when she was treated with electrodermal biofeedback combined with cognitive–behavioral therapy. After 10 sessions, the patient experienced no further seizures.24

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<th>Condition</th>
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<td>Efficacious (based on randomized studies)</td>
<td>Attention-deficit disorder</td>
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<td>Headache—adult</td>
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<td>Hypertension</td>
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<td>Temporomandibular disorders</td>
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<td>Urinary incontinence in males</td>
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<td>Probably efficacious (based on multiple nonrandomized studies)</td>
<td>Alcoholism/substance abuse</td>
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<td>Chronic pain</td>
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<td>Headache—pediatric headache</td>
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<td>Insomnia</td>
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<td>Possibly efficacious (based on at least one study of sufficient statistical power with a well-identified outcome but lacking randomization)</td>
<td>Asthma</td>
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<td>Cerebral palsy</td>
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<td>Irritable bowel syndrome</td>
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<td>Eating disorders</td>
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<td>Multiple sclerosis</td>
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<td>(excepting disorder-related incontinence)</td>
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<td>Spinal-cord injury</td>
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See ref. 1. This is a truncated list of the AAPB categories for disorders that have been investigated by recent research. In the second column, — indicates that there is no reference in this article about the disorder.

AAPB = Association for Applied Psychophysiology and Biofeedback.

Neuromuscular Rehabilitation

Originally, biofeedback was used to train single-muscle activity in static positions or movement unrelated to the motor-function needs of patients with central nervous system injuries and conditions. But recent technological advances have led to systems that address multiple parameters in task-oriented biofeedback.25

In a within-subject clinical intervention, 28 patients who were 2 months post total hip arthroplasty were assigned to a biofeedback, no feedback, or control group to improve their gait. Both the feedback and nonfeedback groups walked on a treadmill for 15 minutes, 3 times per week, for 8 weeks while attempting to reduce their asymmetrical favoring of one leg. This preliminary
study suggested that treadmill walking, with or without biofeedback, can be of benefit to such patients.26

In a randomized study of 26 French patients within 3 months of onset of stroke with left hemiplegia, 13 received conventional physical therapy and 13 were treated with the addition of standing-balance training by biofeedback in a rehabilitation unit. While patients in both groups had improvement in walking, patients who received biofeedback training had greater improvement in the ability to move their affected limbs.27

Children with spastic cerebral palsy and dynamic equinus (spine) deformity were able to improve their gait via biofeedback training. Compared with 15 children in a conventional exercise program, 21 children who received EMG biofeedback in addition to the exercise regimen had significant improvements in range of motion of the ankle joints, muscle tone of plantar flexors, and overall gait function.28

Mind-Operated Devices for People with Other Disabilities

An exciting potential use of biofeedback being developed is to enable patients with disabilities to control assistive devices mentally. A preliminary study investigating whether people could learn to control a computer using a biofeedback interface answered this question in the affirmative. The majority of 20 volunteers were able to learn to play a computer game using biofeedback, and they learned to use the device after a single training session. The biofeedback interface integrated their galvanic skin responses (GSRs), heart rates, and temperatures, with the GSR measure being the most sensitive measure of control.29

Bladder Dysfunction

Bladder dysfunction affects up to 90 percent of patients with multiple sclerosis, but little research has been conducted on biofeedback as an intervention for this problem in this population.

A randomized, double-blinded pilot study of 30 female patients examined the effectiveness of several modalities including EMG biofeedback, neuromuscular electrical stimulation, and pelvic-floor training and advice. After 9 weeks of treatment, the group that received EMG biofeedback training, either in combination with pelvic-floor training or with pelvic-floor training plus neuromuscular electrical stimulation, had greater improvement than the patients who had pelvic-floor training alone.30

A systematic review of 24 controlled trials between 1995 and 2005 of treatments for the common condition of stress urinary incontinence in women concluded that pelvic-floor muscle training, with or without adjunctive therapies including biofeedback, proved to be effective.31

Urinary incontinence is also frequently experienced by men who undergo radical prostatectomy to treat prostate cancer. In a prospective, controlled study of 125 men, ages 53–68, who elected to have this surgery, patients were randomized to either receive preoperative biofeedback-assisted behavioral training for decreasing the duration and severity of incontinence or the usual preoperative instructions to interrupt the urinary stream. Preoperative training significantly decreased the time to recovery of urinary control, and the proportion of patients with severe or continual leakage at the 6-month endpoint (5.9 percent versus 19.6 percent) of the study.32

In a randomized, controlled study of 192 children, ages 6–16, with nonneurogenic bladder-sphincter dyssynergia, home uroflowmetry biofeedback training proved to be a useful adjunctive treatment to standard therapy for this voiding disorder. The biofeedback training produced greater relief than either standard outpatient behavioral therapy or a home educational video together with standard therapy.33

In a Brazilian pilot study of 17 children, ages 3–14, with lower urinary-tract voiding dysfunction, complete clinical improvement was seen in 10, significant improvement occurred in 2, and mild improvement occurred in 5, after a mean of 6 biofeedback sessions. Another 22 children with urge incontinence were treated with transcutaneous electrical stimulation. Of 21 children with nocturnal enuresis, bedwetting continued in 13 whether they received biofeedback or electrostimulation.34

Anorectal Dysfunction

A Dutch cohort study of 281 patients (252 of whom were females) with fecal incontinence explored pelvic-floor muscle rehabilitation via 9 sessions of biofeedback training and electrical stimulation. Outcomes, as measured by Vaizey score (which ranges from 1-continent to 24-totally incontinent), improved from baseline in 60 percent of patients who completed the study, remained unchanged in 23 percent, and deteriorated in 17 percent.35

Eighty-four patients (84; 63 females, 21 males) in an Italian rehabilitation program for functional constipation were treated by biofeedback of the pelvic floor in combination with electrostimulation and physiokinesitherapy. Patients underwent three 1-hour sessions per week for 15 consecutive sessions, followed by 6 sessions every 3 months. At 1 year, 77 patients (92 percent) reported achieving regular intestinal activity without using laxatives and/or cathartics.36

Other researchers have also concluded that biofeedback is superior to laxatives for treating constipation that results from pelvic-floor dyssynergia (PFD), a common type of constipation defined by the inability to relax pelvic floor muscles during defecation.
In a study comparing biofeedback with laxatives plus patient education, 5 biofeedback sessions were more effective than continuous use of polyethylene glycol (14.6–29.2 g per day) for treating PFD for at least 2 years.37

Because of the high risks involved in surgery for treating internal rectal intussusception (a type of prolapse), safe and effective alternative treatments are being sought. In 34 patients (27 women, 7 men) with this disorder who underwent at least 2 biofeedback sessions, 33 percent experienced complete resolution of their symptoms, 19 percent had partial improvement, and 48 percent had no improvement. Patients with constipation symptoms lasting less than 9 years had a 78 percent success rate versus 13 percent in patients who had experienced constipation problems for a longer time. In 7 patients with incontinence, the frequency of daily episodes decreased somewhat after biofeedback.38

Substance Abuse

One hundred and twenty-one (121) volunteers from a mixed substance-abusing inpatient population were randomly assigned to an EEG biofeedback or control group. The patients in the biofeedback group received training in effecting beta and alpha–theta brainwave patterns and sensorimotor rhythm to address attentional variables. Baseline data were obtained on a double-blinded basis as to group placement on standard cognitive and psychometric measures.

Patients in the experimental group had significant improvement on the Test of Variables of Attention and remained in treatment longer than the control group. Of participants who completed the protocol, 77 percent were drug- and alcohol-abstinent at 12 months compared with 44 percent in the control group.39

Other Conditions

In the case of Raynaud’s disease, in which patients experience cold, painful extremities caused by circulatory problems, biofeedback may help mitigate these symptoms via training to raise hand temperature. Successful acquisition of this skill, however, varied by biofeedback protocol. Whereas 67 percent of patients learned hand-warming via feedback on normal temperature, only 55 percent of the EMG biofeedback group learned this physiologic response.40

In a review of research on biofeedback for phonatory disorders and phonatory performance, in only 3 of 18 studies (few randomized, controlled ones) did biofeedback therapy fail to improve voice quality or not yield better results than other therapies.41

In a study of biofeedback applications for visual problems, patients with reduced visual acuity resulting from macular degeneration or other ocular disorders underwent visual rehabilitation using a specially adapted biofeedback instrument. Of the 144 patients/224 affected eyes, training improved visual acuity in 73 percent of the patients’ eyes. (Of the total patients/eyes, 34 patients/47 eyes had received placebo training.)42

Biofeedback also shows some promise as a modality in treating asthma,43 tinnitus,44 irritable bowel syndrome,45 fibromyalgia,46 insomnia,47 and vestibular loss–related balance impairment.48

Efficacy Versus Clinical Effectiveness: The AAPB Guidelines

Practitioners are well-aware that, while a treatment’s efficacy is determined by evaluating formal studies; its efficacy thus assessed may be greater or lesser than its effectiveness in treating their patients. Taking this reality into account, the AAPB has established ratings of efficacy for biofeedback in treating many conditions. (See Table 1.)

Mechanisms of Action

Biofeedback provides assistive tools that help patients become aware of how their bodies are functioning and, consequently, enables them to learn to self-regulate the targeted pattern of physiologic functioning. For example, treatments for pain teach patients to control blood flow and muscle tension. Patients with urinary incontinence are instructed to control pelvic-floor muscles to prevent frequent or uncontrolled urination. Changing brainwave patterns, or operant conditioning of the brain, is the goal of treatment for ADHD and other cognitive disorders.

Karen Olness, M.D., a professor of medicine at Case Western Reserve University, in Cleveland, Ohio, has demonstrated that children can be taught biofeedback techniques to reduce the number of migraines these children experience.

Dr. Olness noted that Herbert Benson, M.D., a professor of medicine at Harvard University, Cambridge, Massachusetts, and founding president of the Mind-Body Medical Institute, Chestnut Hill, Massachusetts, had said that he could not differentiate among different relaxation techniques such as biofeedback, meditation, self-hypnosis, and imagery in terms of brainwave pattern, heart rate, or other physiologic indicators. What they appear to share in common is the process of self-regulation.49

Given the association of relaxation techniques with such changes in vascular tone as decreases in heart rate, metabolism, blood pressure, and rate of respiration, and an increase in skin temperature, one hypothesis holds that nitric oxide, a demonstratated vasodilator, contributes to the physiologic activities of approaches including biofeedback.50

Conclusions

Biofeedback provides tangible representation of subjective observations. Via the principles of operant conditioning, self-regulation, and relaxation, biofeedback is a therapeutic technology that empowers patients to be active participants in their own health care by providing them with immediate insight into the functioning of their bodies.

Biofeedback’s various techniques are safe and adaptable for use by pediatric as well as adult patients. Biofeedback is well-established as an adjunctive treatment modality for chronic pain conditions such as migraine, and support is accruing from recent studies of the efficacy of biofeedback alone or in conjunction with other modalities for treating other conditions, including ADHD, hypertension, and incontinence.
Additional research is warranted on the treatment of the various conditions for which biofeedback has shown potential efficacy. Further studies are also needed to identify which patients are most likely to benefit from specific biofeedback approaches.

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Clinical Efficacy of Psychophysiological Assessments and Biofeedback

Interventions for Chronic Pain Disorders other than Head Area Pain

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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., pelvic pain, Raynauds syndrome) to not empirically supported (e.g. complex regional pain syndrome / 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 complex regional pain syndrome (A.K.A. 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 most pain problems, 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 tension related jaw pain and cramping phantom limb pain, or (2) significantly decreased blood flow to a specific area as may be found in early complex regional pain syndrome (CRPS) 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 psychological mechanisms as noted above, etc. Thus, chronic pain is most often not 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, & Marbach, 1996). 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, Geisser et al (2005) conducted a meta-analytic review of surface electromyography (SEMG) among persons with low back pain and healthy controls. They concluded that “SEMG measures of flexion-relaxation appear to distinguish LBP subjects from controls with good accuracy”.

Figure 1 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, et al., 1996). Figure 2 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 five 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) 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 1. 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 2. 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) with 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) or Flor (2002a). For an ‘in depth’ look at the entire area of phantom pain, one might read the book Phantom Pain by Sherman, et al.,(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 et al., 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. Both Belleggia and Birbaumer (2001) and Harden, Houle, Green et al. (2005) have used these methods successfully.

**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, perform muscle tension biofeedback from the residual limb in conjunction with muscle tension awareness and control training. The intervention may take as many as ten sessions (usually twice per week) during which the patient watches the raw muscle tension signal (SEMG) recorded from the major muscles of the residual limb on a display screen and attempts to stop the spasms preceding bursts of phantom pain. 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. Two main assessment strategies have been followed. One approach focuses on the assessment of muscle activity related to physical activity such as different body postures and movements. 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 EMG recordings 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 requires all subjects to keep logs of their perceived stress intensities (Sherman, et al., 1992, 1993, 1996).

A second approach for understanding the role of psychophysiological response patterns in chronic musculoskeletal pain has looked at muscular activity elicited by exposure to stress. Based on a comprehensive review of studies on patterns of stress-dependent psychophysiological activity in chronic back pain, Flor and Turk (1989) argued that standard stress tasks such as mental arithmetic are not particularly well suited to detect stress-dependent and symptom-specific response patterns. They concluded that personally relevant stressors are most likely to unravel symptom-specific 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 positions 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 spasmmed 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 spindle 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.

**Overreactivity in Response to an Innocuous Stimulus:** Flor's group has been able to classically condition forearm muscle responses to stimuli which originally were not pain-related (Flor et al., 1996; Schneider, Palomba, & Flor, 2004). Such learning processes can result in a stereotyped response to a variety of stimuli which originally elicited no or only a minimal response in the musculoskeletal system. 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 mental stressors (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 and, Olesen (1993) and Bendtsen, Jensen and 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 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, 90 to 94 % of the cervical and headache patients had abnormal levels while only 9 to 19 % of the normals had abnormal levels.

The above evidence shows that there is a strong relationship between posture related pain and abnormal levels of muscle tension, Hence, correction of abnormal muscle tension and correction of posture may result 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; Arena and Blanchard, 2002) and it is frequently impossible to determine whether the psychophysiological intervention had any effect or even just how it was applied. A major problem with multimodal programs which simultaneously deliver several interventions is that they preclude conclusions about the effectiveness of any particular intervention. Moreover, one cannot learn anything about how to apply a certain intervention (e.g., treatment length) such that it produces a clinical effect.

Flor's group (e.g., Flor & Birbaumer, 1993) 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 & Birbaumer, 1994). Patients participated in eight to twelve biofeedback sessions of 60 min duration 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. In a previous small-scale study of the same group (Flor, Haag, & Turk, 1986) EMG biofeedback was evaluated in 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, and Shotte (1995) compared a cognitive behavioral treatment (CBT) program, EMG biofeedback and a wait list control condition in chronic back patients. Both CBT and EMG-biofeedback showed similar beneficial effects and were both superior to the wait-list control group. Effects persisted at a six-month follow-up. There were no differences in effectiveness between CBT and EMG-biofeedback. Vlaeyen and colleagues (Vlaeyen, Haazen, Schuerman, Kole-Snijders, & van Eek, 1995) studied the differential effectiveness of EMG biofeedback combined with operant treatment, cognitive-operant treatment and an operant treatment program in 71 low back pain patients. All treatment groups yielded significantly
greater improvement than the wait-list control. In addition, the combined programs, i.e. EMG-biofeedback plus operant and cognitive-operant treatment, were more efficacious than the operant alone treatment in reducing pain behaviors, increasing healthy behaviors and perceived self-efficacy.

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 reported 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.

Sherman and Arena (1992) and Arena and Blanchard (2002) have extensively reviewed the literature on the use of psychophysiological techniques for treatment of low back pain (see also Morley, Eccleston & Williams, 1999). Sherman and Arena’s (1992) review of twenty-nine clinical studies as well as the authors' 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 about half of the studies have sample sizes over nine.
- Only a few specify the diagnostic methodology.
- Less than half of the studies have any controls (e.g. waiting lists, etc.)
- Only a few factored changes in medication into their results.
- Only very few had follow-ups of six months or more.
- Only several had subjects keep pain diaries or had multiple objective outcome measures.

Gevirtz, Hubbard and 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. However, 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. This lack of larger-scale randomized controlled trials (RCTs) on the effectiveness of psychophysiological interventions becomes apparent in the systematic and repeatedly updated reviews of RCTs by the "Cochrane Back Review Group". This group of researchers provides up-to-date reviews of RCTs for chronic back pain based on the guidelines of the Cochrane collaboration (http://www.cochrane.org; Bouter, Pennick, & Bombardier, 2003). Since 1997, several such reviews have been published (e.g., Ostelo et al., 2006; van Tulder, Koes, & Bouter, 1997; van Tulder et al., 2001; van Tulder & Koes, 2004). In light of the dearth of RCTs on psychophysiological interventions for chronic back pain, these reviews do not list biofeedback as a well-established treatment. Clearly, there is a need for RCTs which would help promoting biofeedback as an empirically validated intervention for chronic back pain.

**Specific Protocols:** Most people applying the techniques involved with retraining muscles to tense correctly (e.g., Ettare & 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 level is reached, the threshold is reset so the next goal 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 obvious and patients report rapid resolution of the problem. Figure 3 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 3.** 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.

![EMG recordings of bilateral paraspinal muscle activity](image)

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, virtually the same protocol as described for headaches can be used 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.

**Typical protocol:** 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 cannot 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 authors' 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 very brief 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 these muscular problems and to correct them immediately. When dealing with people
who do manual labor, the therapist should be 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. 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. 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 (1999) 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. As compared to a waiting-list control group, treatment significantly reduced the number of chest pain episodes (median pre: 6.5 per week to post 2.5 per week). In addition, anxiety and depression scores as well as perceived disability decreased, and exercise tolerance increased. These improvements were maintained at six month follow-up. Treatment reduced the prevalence of hyperventilation from 54% to 34%, but the prevalence of ECG-positive exercise tests was unaltered. Patients continuing to attribute their pain to heart disease had poorer outcomes.

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 (HRV) 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 breathing 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, but not the control subjects showed a significant increase in SDNN from baseline to week 6 and to week 18.

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 pelvic floor related pain disorders including chronic pelvic pain of unknown origin, premenstrual syndrome (PMS), Dysmenorrhea, Vulvar vestibulitis, and 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 Bentham (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 skin conductance 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 & 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. Studies such as that by Hetrick et al. (2006) clearly support the ability of SEMG evaluations to differentiate between men with chronic pelvic pain syndrome and pain free controls. Similar studies of women with vulvar vestibulitis show that muscle functioning is different among women with and without the problem (Reissing, Brown, Lord, Binik & Khalife, 2005). Clinical studies show that muscle tension biofeedback is an effective intervention for pelvic floor pain of unknown etiology for adults (Nadler, 2002) and children (Hoebke et al., 2004). The technique is clearly effective for men with chronic pelvic pain syndrome (Clemens, Nadler, Schaeffer, Belani, Albaugh & Bushman, 2000, Cornel, van Haarst, Schaarsberg & Geels, 2005). However, there are no controlled studies of biofeedback for pelvic pain which compare the effectiveness of biofeedback with other techniques or placebos. 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. McKay et al (2001) found that 20 of 29 women treated with biofeedback were able to become sexually active and to control their vulvar vestibulitis related pain after SEMG biofeedback.

Turnbull and Ritvo (1992) used biofeedback and relaxation exercises to treat painful constipation among five women. Pain decreased significantly along with the other symptoms. Palsson, Heymen and Whitehead (2004) found three studies on the use of biofeedback to relieve anorectal pain which showed that the technique was efficacious.

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 4. White, Jantos and Glazer (1997) have found similar patterns and published good illustrations of what can be expected before and after therapy.
Figure 4. 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.*

- 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 & 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 intersubject 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>
<thead>
<tr>
<th>Table 1. Efficacy Ratings of Chronic Pain Disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Efficacious and specific (Fifth level):</strong></td>
</tr>
<tr>
<td>(b) Tension headache in both adults and children (Review by Blanchard 1992)</td>
</tr>
<tr>
<td><strong>Efficacious (Fourth Level):</strong></td>
</tr>
<tr>
<td>(a) <em>Muscle related orofacial pain (reviews by Glaros &amp; Lausten, 2002, Crider, Glaros &amp; Gevirtz 2005).</em></td>
</tr>
<tr>
<td>(b) Irritable bowel syndrome (differing reviews, by Blanchard, 1993, and by Humphries &amp; Gevirtz, 2000)</td>
</tr>
<tr>
<td>(c) <em>Anxiety related to incorrect breathing patterns causing non-cardiac chest pain (Reviews by Gevirtz, 2001, DeGuire, Gevirtz, Hawkinson, &amp; Dixon, 1996).</em></td>
</tr>
</tbody>
</table>
(d) 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 & Birbaumer, 1994; Morley, Eccleston & Williams, 1999; van Tulder et al., 2006)
(b) Cramping and burning phantom limb pain (Belleggia & Birbaumer, 2001, Harden et al., 2005, Reviews by Sherman, Devore, Jones, Katz, & Marbach, 1996, Flor, 2002b)
(c) PMS and Dysmenorrhea (Breckenridge, 1983)
(d) Pain from spastic muscles and muscle spasms (Kasman, 1998)
(e) Magnification of pain by stress & anxiety (Yucha & Gilbert, 2004)
(g) Subluxation of the Patella and patelofemoral pain (Ingersoll & Knight, 1991, Crossley, Bennell, Green, Cowan & McConnell, 2002, Dursun, Dursun & Kilic, 2001)

Possibly Efficacious (Second level):

(a) Pain from carpel tunnel syndromes related to upper arm and neck muscle tension (reviews by Donaldson, Nelson, Skubick, & Clasby, 1998; Skubick, Clasby, Donaldson, & Marshall, 1993)
(b) Myofascial pain syndrome / trigger point related pain (reviews by Headley, 1991; Gevirtz, 1995)
(c) Raynaud's syndrome (Review by Freedman, 1991)
(d) Repetitive strain injury (Moore & Weisner, 1996)
(e) Fibromyalgia (Buckelew, Conway, Parker et al 1998, Drexler, Mur & Gunther, 2002; Ferraccioli et al., 1987; Ferraccioli et al., 1987 Mueller, Donaldson, Nelson & Layman, 2001; van Stanten et al., 2002)

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 complex regional pain syndrome (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.

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Introduction to Chinese Medicine

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Whole System

• Traditional Chinese medicine includes several treatment modalities that together form a system of medicine.

• Modalities include acupuncture, moxibustion, bodywork, exercise therapy, and the internal and external uses of herbs
Bastyr’s Integrated Pain Shift
Chinese Medicine Modalities

• Acupuncture-moxibustion (針灸) to move and warm blocked circulation

• Cupping – to release muscle tension eliminate pathogens

• Tui-na (推拿) massage – to release muscle tension

• Qi-gong (氣功) exercise “homework” – to balance the system by self-regulation

• Chinese herbal medicine (中藥) – tonifies essential substances, moves and circulates, removes pathogens
Traditional? Chinese?

• Beginning in the 1600’s, Dutch and then French travelers brought Chinese medical information to Europe, starting its interpretation by European thinkers.

• Traditional Chinese Medicine (TCM) as practiced world-wide, is an amalgam of modern scientific biomedicine and traditional diagnosis and treatment methods.
Roots of TCM Theory

• Very early magico-religious practices
• Taoism
• Confucianism

Out of these roots evolved a number of classical texts that still form the basis of TCM practice even as it integrates with modern medicine.
Some Classic Texts of TCM

Acupuncture-moxibustion:
• Huang Di Nei Jing (Yellow Emperor’s Classic of Internal Medicine) 1st-2nd centuries, B.C.E.
• Nan Jing (Classic of Difficult Questions) 1st century, C.E.

Herbal Medicine:
• Shang Han Lun (Treatise on Cold Damage) Circa 220 C.E.
• Wen Yi Lun (Treatise on Warm Epidemics) 1642 C.E.
Diagnostic Rubrics of TCM used to describe illness

• Yin and yang
• 8 Principles (hot-cold, interior-exterior, excess-deficient, yin-yang)
• Qi, blood, and fluids
• Organ and channel
• Environmental Pathogenic factors (heat, cold, wind, damp, dryness, summerheat, fire)
• 5 elements (wood, fire, earth, metal, water)
• 6 Divisions (levels of cold injury)
• 4 Stages and 3 Burners (levels of heat disease)
One Problem = Many TCM Diagnoses

• One bio-medically defined problem might be diagnosed under several of the rubrics.
• Different cases of back pain, for instance, might have different diagnoses and thus treatment will differ.
• This applies to internal medicine as well as orthopedics. Two cases of malaria could be given two separate diagnoses in TCM.
Information from the Patient

• We use asking questions, listening to sounds, feeling the pulse, observing the tongue and palpating the body/channels to gather information.

• The information will form a pattern that guides treatment using our modalities.
Example Cases of Back Pain


• Case Two: Wiry, stiff housepainter with spondylolisthesis aggravated by lifting. Tongue: Red with no coat. Pulse: Thin and tight. Diagnosis: Yin Deficiency with Qi and Blood stagnation.
Different Treatments

• Case One and Case Two might have similar local acupuncture around the area of pain since similar channels are involved.

• The constitutional herbs and acupuncture for each case would be quite different.

• Exercise recommendations would be quite different.
What is TCM Good For?

• As a whole system, TCM treats all medical complaints, as it has been evolving as long as bio-medicine.

• Acupuncture is recommended by the World Health Organization for a long list of medical conditions.

• See the WHO website’s “Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials” 2003, 87 pp.
TCM and PAIN

• Although acupuncture has most news exposure, the modalities of TCM can each contribute to alleviating pain.

• Acupuncture is useful for any pain, especially when there is a structural cause of pain, when impaired circulation is a factor, when anxiety amplifies pain, or when neuropathy is present.
Theories As to How Acupuncture Works for Pain

• Activates endorphin release
• Relaxes muscle fibers
• Increases circulation
• Spinal gate theory
• Displaces tissue via fascial system
• All of the above
We Do Not Understand It Yet

Research is ongoing as to the mechanisms, effects, and efficacy of acupuncture and other TCM modalities.
Recommended Reading

Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials. 2003; World Health Organization nonserial publication

Scheid V. Not very traditional, nor exactly Chinese, so what kind of medicine is it? TCM’s discourse on menopause and its implications for practice, teaching and research. *J Chin Med.* 2006;82: 5-19


Hanson, M. *Speaking of Epidemics in Chinese Medicine:Disease and the Geographic Imagination in Late Imperial China.* Routledge;2011


Where to Get More Information

• Society for Acupuncture Research
  www.acupunctureresearch.org/

• Washington East Asian Medicine Association
  www.weama.info/
Articles

Acupuncture Analgesia: I. The Scientific Basis

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Zeev N. Kain, MD, MBA†‡
Paul White, PhD, MD§

Acupuncture has been used in China and other Asian countries for the past 3000 yr. Recently, this technique has been gaining increased popularity among physicians and patients in the United States. Even though acupuncture-induced analgesia is being used in many pain management programs in the United States, the mechanism of action remains unclear. Studies suggest that acupuncture and related techniques trigger a sequence of events that include the release of neurotransmitters, endogenous opioid-like substances, and activation of c-fos within the central nervous system. Recent developments in central nervous system imaging techniques allow scientists to better evaluate the chain of events that occur after acupuncture-induced stimulation. In this review article we examine current biophysiological and imaging studies that explore the mechanisms of acupuncture analgesia.

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TRADITIONAL ACUPUNCTURE THEORY

Traditional Chinese acupuncture is a philosophy that focuses more on prevention than treatment of illnesses. The Chinese medical acupuncture philosophy presumes that there are two opposing and complementary forces that coexist in nature: Yin and Yang. These two forces interact to regulate the flow of “vital energy,” known as Qi. When a person is in “good health,” Yin and Yang are in balance, and the flow of Qi is smooth and regular. When Yin and Yang become “unbalanced,” there are disturbances in Qi, which lead to illness and disease. The ancient Chinese believed that Qi flows through a network of channels called meridians, which bring
Qi from the internal organs to the skin surface. Along these meridians there are acupuncture points that can be stimulated to correct the imbalance and restore the body to normal health.1

MODERN ACUPUNCTURE THEORY

The traditional Chinese perspective is not based on anatomical, physiological, or biochemical evidence, and thus cannot form the basis of a mechanistic understanding of acupuncture. Western theories are primarily based on the presumption that acupuncture induces signals in afferent nerves that modulate spinal signal transmission and pain perception in the brain. In 1987, Pomeranz proposed that acupuncture stimulation activates A-δ and C afferent fibers in muscle, causing signals to be transmitted to the spinal cord, which then results in a local release of dynorphin and enkephalins. These afferent pathways propagate to the midbrain, triggering a sequence of excitatory and inhibitory mediators in the spinal cord. The resultant release of neurotransmitters, such as serotonin, dopamine, and norepinephrine onto the spinal cord leads to pre and postsynaptic inhibition and suppression of the pain transmission. When these signals reach the hypothalamus and pituitary, they trigger the release of adrenocorticotropic hormones (ACTH) and endorphins. Pomeranz’s theory was confirmed by a large series of experiments by his research laboratory and other investigators.8–17 This conceptual framework for acupuncture-induced analgesia has also been investigated in a series of neurophysiologic and imaging studies over the last three decades.

Neurophysiological Studies

Volunteer Data

One of the first volunteer studies that examined the scientific basis of acupuncture analgesia was published in 1973 by a group of investigators who used a model of acute pain mediated by potassium iontophoresis with gradual increases of electrical current.9 The volunteers were randomized to receive acupuncture at large intestine 4 (LI4) (Fig. 1) and stomach 36 (ST36) (Fig. 2) or IM morphine. The investigators found that both acupuncture and morphine increased the subjects’ pain threshold by an average of 80%–90%. The acupuncture-induced increase in the pain threshold was gradual, with a peak effect at 20–40 min, followed by an exponential decay with a half-life of approximately 16 min, despite continued acupuncture stimulation.9 Importantly, when the researchers injected local anesthetic into these acupuncture points before the stimulation, the acupuncture became ineffective in increasing the pain threshold (Fig. 3). This suggested that an intact sensory nervous system is essential for the transmission of acupuncture signals. The investigators also found that the analgesic effect was the same regardless of which side of the body was stimulated. Finally, a greater cumulative effect was observed when multiple acupuncture points were stimulated simultaneously.

In a follow-up study, Lim et al.10 found that direct stimulation of peripheral nerve sensory fibers increased the pain threshold in a manner similar to that caused by standard acupuncture technique. These findings are remarkably consistent with the findings from a more recent clinical study involving the use of transcutaneous electrical stimulation for minimizing postoperative pain.18

Experimental Data

The difficulty in developing suitable animal models has been one of the major obstacles in the experimental study of the mechanism of acupuncture anesthesia.11 Professor Han and his colleagues at Peking
University performed multiple trials using various animal models in search of the ideal experimental model for acupuncture research. The investigators initially used a rabbit model, but later adopted a rat model because rats are commonly used in pain research and are easier to handle.

In 1973, Professor Han and his colleagues applied acupuncture stimulation to a rabbit for 30 min to achieve an analgesic effect. The cerebrospinal fluid (CSF) was then removed and infused into the lateral ventricle of an acupuncture-naive recipient rabbit. This resulted in an increase in the pain threshold in the recipient rabbit. The investigators concluded that acupuncture-induced analgesia was associated with the release of neuromodulatory substances into the CSF. The investigators also noted that there was no increase in analgesic response when saline or CSF from nonacupuncture control was infused into an acupuncture-naive recipient rabbit.

In 1976, Pomeranz and Chiu, using a mouse model, found that administration of the opioid antagonist-naloxone blocked the acupuncture-induced analgesic activity. Similarly, in a human model, Sjolund and Ericksson, as well as Mayer, were able to demonstrate increased levels of endorphins in CSF after EA stimulation, and the reversal of acupuncture analgesia by naloxone. This again suggested the involvement of endorphins in human acupuncture analgesia. Several subsequent studies supported the hypothesis that acupuncture triggers the release of endorphins and other endogenous opioids within the central nervous system (CNS), and this appears to be responsible for the analgesic properties of acupuncture.

Recent EA studies also indicate that low-frequency EA induces the release of enkephalin and β-endorphin, whereas high-frequency EA induces the release of dynorphin.

The development of tolerance to EA analgesia was first described in 1979 after the observation that the duration of the acupuncture analgesic effect was not directly correlated to the duration of acupuncture administration. In a follow-up study, this research group described that EA applied to a rat model for a 30-min period increased the pain threshold by 89%. When the EA stimulation was repeated over six consecutive sessions with 30 min between each session, however, the resulting analgesic effect diminished progressively and eventually returned to a baseline level. This tolerance to acupuncture analgesia is thought to be the result of desensitization or “down regulation” of CNS opioid receptors, as well as the release of antiopioids such as cholecystokinin octapeptide. Subsequently, Han et al. were able to reverse acupuncture tolerance by an intraventricular injection of cholecystokinin antiserum in a group of rats which received continuous 6-h EA stimulation.

Guo et al. investigated whether high-frequency EA differs from low-frequency EA in gene expression using c-fos as a marker of activation in various parts of the rat brain. These investigators found that low-frequency EA resulted in much higher c-fos expression in the arcuate nucleus when compared with that after high-frequency stimulation, and when compared with that after simple needle insertion into an acupoint without electrical stimulation in a control group. In situ hybridization studies revealed that low-frequency stimulation increased the expression of messenger RNA for the enkephalin precursor protein, whereas high-frequency stimulation increased the expression of mRNA for the dynorphin precursor protein. Thus, there appear to be differential effects of low versus high-frequency EA stimulation on c-fos expression, as well as on the transcription of mRNA by various opioid genes in the brain. However, c-fos expression can also be caused by nonspecific stimulations (e.g., immobilization or handling of the animal). Furthermore, mRNA levels may not correlate with actual peptide levels. It is important to note that while these studies suggest EA analgesia is at least partly mediated through endogenous opioids, further work is required.

Pan et al.31–33 studied whether there is an overlap of central pathways between noxious stimulation and acupuncture stimulation in rats. These investigators found that noxious stimulation (caused by immersing the footpad into 52°C water) and EA (4 Hz) both induced c-fos expression in the anterior lobe of the pituitary gland and in the arcuate nucleus as well as in nearby hypothalamic nuclei. These researchers also found similar c-fos expression in the anterior lobe of the pituitary gland in response to immobilization stress in awake rats. It seems that, although the anterior pituitary cells that respond to stress are activated by both acupuncture and pain stimulation, the mechanism of pituitary cell activation seems distinct from the activation occurring in stress because different hypothalamus nuclei are involved.31 A follow-up study by the same research team was conducted to identify the function of these activated pituitary cells.32 The investigators found that fos-immunoreactive cells activated by noxious stimulation or EA, co-localized with adrenocorticotropic hormone or thyroid-stimulating hormone, and that noxious stimulation and EA were associated with a similar rise in plasma adrenocorticotropic hormone and β-endorphin. At the hypothalamic level, c-fos expression was increased in the mediobasal nuclei (mainly arcuate nucleus and adjacent nuclei) and in the paraventricular nucleus after EA stimulation, but not after noxious stimulation. These data suggested that both somatosensory noxious input and EA activate the hypothalamic-pituitary-adrenocortical axis analogous to stress, but with a specific activation of the mediobasal hypothalamic nuclei, and no activation of intermediate lobe.

Pan et al.33 confirmed that intact nociceptive primary afferent input is needed to transmit both EA and noxious stimulation signals to the CNS. These investigators found that neither noxious stimulation nor EA stimulation activated the hypothalamic-pituitary-adrenocortical axis or increased plasma ACTH in rats after sensory deafferentation by subcutaneous capsaicin injection to eliminate nociceptive primary afferent input. In contrast, immobilization stress caused a decrease in c-fos activation in the hypothalamic pituitary, with no decrease in plasma ACTH.33 Thus, both noxious stimulation (i.e., pain) and EA activated the hypothalamic-pituitary-adrenocortical axis in a similar fashion. Thus, there appears to be a significant overlap in pain and acupuncture central pathways.

Choi et al.34 studied the effects of three frequencies of EA (2, 15, and 120 Hz) on chemically induced inflammation of the rat hindpaw. These investigators found that the edema and mechanical sensitivity of rats’ hindpaws were strongly inhibited by EA through modulating expression of ionotropic glutamate receptors, particularly N-methyl-D-aspartate receptor in the dorsal horn of the spinal cord. Unfortunately, there was no sham-control intervention in this study. Therefore, the phenomena observed may not directly relate to acupuncture alone.

Several conclusions can be made based on the above neurophysiologic studies. First, afferent nociceptive pathways are essential for acupuncture analgesia. Second, acupuncture analgesia is mediated by way of various endogenous neurotransmitters, systemic release of enkephalin and dynorphin, and probably by decreasing the local inflammatory response via N-methyl-D-aspartate receptors. Third, the acupuncture-induced increase in pain threshold is gradual, with a peak effect at 20–40 min, followed by an exponential decay with a half-life of approximately 16 min. Fourth, a prolonged period of acupuncture stimulation results in tolerance that is mediated via release of cholecystokinin octapeptide. Lastly, immunocytochemistry studies indicate that both pain and acupuncture activate the hypothalamic-pituitary-adrenocortical axis.

CNS Imaging Studies

Over the last decade, advanced imaging technologies have been introduced, including positron emission tomography (PET), single-proton emission computer tomography (SPECT), and functional magnetic resonance imaging (fMRI). These powerful imaging technologies have made it possible to noninvasively visualize the anatomic and functional effects of acupuncture stimulation in the human brain.

PET Studies

Using PET imaging, Alavi et al.35 observed that a group of patients who suffered from chronic pain also had asymmetry of the thalamus. This thalamic asymmetry disappeared after acupuncture treatment. One should note, however, that the study did not include a sham-control group. As a result, the PET-related changes do not necessarily indicate a cause-effect relationship.

The “De Qi” sensation is frequently described by patients as soreness, numbness, ache, fullness, or warm sensation that is achieved during manipulation of the acupuncture needles.1,2 This sensation coincides with acupuncturists describing a feeling of the needle being caught as it is twirled (e.g., “the fish took the bait” or “the needle is stuck to a magnet”).36 Wang et al.37 suggested that type II afferent fibers are responsible for the sensation of numbness, type III afferent fibers are responsible for fullness (heavy, mild ache), and type IV afferent fibers are responsible for soreness. Hsieh et al.38 used PET images to visualize the effect of De Qi sensation. This study compared acupuncture stimulation at a frequency of 2 Hz that was associated with a De Qi sensation at LI4 (Fig. 1) to the same stimulation at a sham-acupuncture point as well as to superficial insertion of a needle with minimal stimulation at LI4 and to a superficial insertion of...
a needle at a sham-acupuncture point. The investigators found that only acupuncture stimulation at LI4 with De Qi sensation activated the hypothalamus. Thus, the De Qi at an acupuncture point appears to be the conscious perception of the nociceptive input from the acupuncture stimulation. Biella et al.39 sequentially applied acupuncture and sham acupuncture at bilateral ST36 (Fig. 2) and LI5 (Fig. 1) during a PET scanning sequence and found that acupuncture, but not sham treatment, activated the left anterior cingulum, superior frontal gyrus, bilateral cerebellum, and insula, as well as the right medial and inferior frontal gyri. These are the same areas activated by acute and chronic pain.40–48 This finding suggests a possible mechanism for acupuncture analgesia.

Pariente et al.49 suggested that, in addition to the direct analgesic effect of acupuncture, the anticipation and belief of a patient might also affect the level of therapeutic outcome. Using PET image, these investigators reported that both true and sham acupuncture activated the right dorsolateral prefrontal cortex, anterior cingulated cortex, and midbrain. The investigators suggested that these CNS areas are involved in nonspecific factors such as expectation. The investigators also found, however, that only true acupuncture caused a greater activation in insula ipsilateral to the site of stimulation. Based on the above, one can conclude that the insula region of the brain has a specific role in acupuncture analgesia.

**SPECT Studies**

Newberg et al.50 used radioisotope hexamethylpropyleneamine oxime to image the brain of patients suffering from chronic pain and healthy volunteers without pain. The investigators found significant asymmetric uptake in the thalamic regions of patients with chronic pain, but not in the healthy control group. After 20–25 min of acupuncture stimulation, another hexamethylpropyleneamine oxime was administered to these patients and a repeated SPECT study showed that the original asymmetry reversed or normalized after acupuncture therapy that coincided with the reduction of pain. This finding is analogous to the findings in PET studies reported by Alavi et al.51

**fMRI Studies**

**Manual Acupuncture Stimulation.** Wu et al.52 found that traditional acupuncture stimulation activated the hypothalamus and nucleus accumbens, but deactivated the rostral part of the anterior cingulate cortex, the amygdala formation, and the hippocampal complex. In contrast, minimal acupuncture activated the supplementary motor area and anterior cingulate cortex and frontal as well as parietal operculum. Superficial pricking induced activation at the primary somatosensory cortex, the thalamus, and the anterior cingulate cortex. Hui et al.53 found that needle manipulation associated with the De Qi sensation deactivated the nucleus accumbens, hypothalamus, amygdala, hippocampus, para hippocampus, ventral tegmental area, anterior cingular gyrus, caudate, putamen, temporal lobe, and insula. In a follow-up fMRI study, Hui et al.54 explored the subjective psychological perceptions (mainly, the conscious perception of the nociceptive input from the acupuncture stimulation) in relation to the CNS responses. They found that subjects who experienced De Qi deactivated the frontal pole, ventromedial prefrontal cortex, cingulate cortex, hypothalamus, reticular formation, and the cerebellar vermis. Subjects who experienced pain instead of De Qi sensation activated the anterior cingular gyrus, caudate, putamen, and anterior thalamus. When these subjects experienced both De Qi and pain, the CNS responses were mixed with predominance of activation at the frontal pole, anterior, middle, and posterior cingulate (Fig. 4). Based on the above studies, these investigators suggest that acupuncture and pain may share similar central pathways, but CNS activities triggered by these two stimulations are opposite to each other. Support for this hypothesis is provided by an fMRI study that showed that EA stimulation can modify signals generated by experimental cold pain stimulation.54

Of note are the reported discrepancies between the findings of Wu et al. and Hui et al. with respect to the effect of acupuncture on the hypothalamus and nucleus accumbens. There are several possible reasons for the discrepancies between the two studies. First, duration of acupuncture stimulation was different between these studies (1 min vs 2 min). Second, the conscious perceptions of nociceptive input from acupuncture stimulation experienced by study subjects might be different between these studies. Finally, there might be differences in methodology of fMRI image analysis e.g., correction of motion artifact and threshold setting for noise between these two laboratories.

Ulett et al.6 suggested in 1998 that the periaqueductal gray (PAG) region in the brainstem is associated with perception and modulation of noxious stimuli and has an important role in acupuncture analgesia. In an effort to explore these issues using fMRI technology, Liu et al.55 applied acupuncture stimulation to healthy volunteers at LI4 and observed that PAG activity increased with the increasing length of stimulation, with the activated areas ranging from the left ventral to left dorsal lateral to dorsal medial regions. The frequency of activation of PAG after stimulation of the LI4 was calculated by averaging the total number of activations per run (every run consisted four 30-s periods of “acupuncture on”). These investigators also observed that stimulation at a nonacupuncture point resulted in reduction of PAG activity.

**EA Stimulation.** Wu et al.56 reported that both true and sham EA stimulation at a common analgesic acupuncture, gallbladder 34 (Fig. 2), activated regions of pain central pathways on fMRI.56 The investigators noted, however, that only true EA stimulation activated the hypothalamus, the primary somatosensory...
cortex and the motor cortex, and deactivated the rostral segment of the anterior cingulate cortex. These investigators concluded that the hypothalamus-limbic system was modulated by EA stimulation.

To investigate the direct modulatory effects of EA stimulation in pain responses, Zhang et al.54 studied a group of healthy volunteers using fMRI scanning during experimental cold pain with real or sham EA stimulation. Only the subjects who received EA reported a reduction of pain. The brain images obtained by Zhang et al. showed an acupuncture-induced increased activation in the bilateral somatosensory area, medial prefrontal cortices and Brodmann area (BA32), and a decreased activation in the contralateral primary somatosensory areas BA7 and BA24 (anterior cingulated gyrus). With sham stimulation, there was no observed decrease in pain intensity or fMRI image changes. As these areas are frequently involved in pain stimulation, Zhang et al. concluded that EA induces analgesic effects via modulation of both the sensory and emotional aspects of pain processing. This study again demonstrates

Table 1. The Areas of Brain Affected by Acupuncture Stimulation in Imaging Studies

<table>
<thead>
<tr>
<th>Limbic system</th>
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<tbody>
<tr>
<td>Cingular gyrus</td>
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<tr>
<td>Amygdala</td>
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<tr>
<td>Parahippocampal gyrus</td>
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<tr>
<td>Hippocampal gyrus</td>
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<td>Insula</td>
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<td>Periaqueductal gray</td>
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<td>Thalamus</td>
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<td>Hypothalamus</td>
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<td>Basal ganglia</td>
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<tr>
<td>Putamen</td>
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<tr>
<td>Caudate</td>
</tr>
<tr>
<td>Neucleus accumbens</td>
</tr>
<tr>
<td>Cerebellum</td>
</tr>
<tr>
<td>Brain stem</td>
</tr>
<tr>
<td>Substantis nigra</td>
</tr>
<tr>
<td>Reticular formation</td>
</tr>
<tr>
<td>Pontine nuclei</td>
</tr>
<tr>
<td>Dorsal raphe</td>
</tr>
<tr>
<td>Somatosensory II</td>
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</tbody>
</table>

Figure 4. The influence of subjective sensations on fMRI signal changes on major limbic structures, the secondary somatosensory cortex (SII) and the cerebellum during acupuncture at ST 36. Regions of interest are denoted by yellow arrowheads. (Left) Acupuncture with deqi sensations (N = 11). (Middle) Acupuncture with mixed sensations of deqi and sharp pain (N = 4). (Right) Sensory control (N = 5). (Row A) The amygdala showed signal decrease with acupuncture deqi, increase with sensory stimulation and no significant change with acupuncture mixed sensations. (Row B) The hippocampus, bottom arrows, showed signal decrease with acupuncture deqi, and no significant change otherwise. (Row C) SII, also shown by the right arrows in Row B, shows signal increase under all three stimulations. Acupuncture, being a form of sensory stimulation, would be expected to result in signal increases in SII, which is in stark contrast to the widespread signal decreases during acupuncture deqi. (Row D) With acupuncture deqi, the cerebellum showed signal decreases in the vermis and lobules VI and VII. With sensory control, the lateral hemisphere showed signal increases. Reproduced with permission from Hui et al., Neuroimage, 2005, 27, 479–96, ©Academic Press.
that the hypothalamus-limbic system plays an important role in acupuncture analgesia.

An fMRI study by Zhang et al. found that the low-frequency (2 Hz) EA stimulations activated the contralateral primary motor area, supplementary motor area, and ipsilateral superior temporal gyrus, while deactivating the bilateral hippocampus. In contrast, these investigators found that high-frequency (100 Hz) EA stimulations activated the contralateral inferior parietal lobules, ipsilateral anterior cingulate cortex, nucleus accumbens and pons, while deactivating the contralateral amygdala. Therefore, one can conclude that low and high-frequency EA stimulations appear to be mediated by different brain networks. Thus, alternating high/low-frequency EA stimulations may provide the additional analgesia benefit by activating both systems simultaneously.

Studies Comparing Different Acupuncture Stimulations. Napadow et al. compared manual acupuncture, EA at 2 and 100 Hz, and tactile control stimulation at ST36 in a group of healthy volunteers. They reported that low-frequency EA produced more widespread fMRI signal changes than manual acupuncture stimulation. Not surprisingly, both EA and manual acupuncture produced more widespread responses than simple tactile stimulation. These investigators also found that although acupuncture stimulation activated the anterior insula, it deactivated the limbic and paralimbic structures that include the amygdala, anterior hippocampus, cortices of the subgenual and retrocingulate, ventromedial prefrontal cortex, and frontal and temporal lobes. EA at both high and low frequencies produced a significant signal increase in the anterior middle cingulate cortex; however, only low-frequency EA produced activation at the raphe area. Therefore, fMRI studies support the hypothesis that the limbic system is central to acupuncture-induced analgesia regardless of the specific modalities.

Several conclusions can be made based on the above CNS imaging studies. First, the hypothalamus may play a central role in acupuncture analgesia. Second, the significant overlap between acupuncture and pain CNS pathways suggests that acupuncture stimulation may affect pain signals processed in the CNS. Third, superficial needling and traditional acupuncture needling activate two different central pathways and yet both provide clinical analgesia.

Future studies should on their effects in releasing different opioid-like substances as well as differences in the level of pain relief. The majority of neuroimaging studies in acupuncture are merely explorations of acupuncture signal network. The clinical relevance of data obtained from these studies is unclear. Indeed, participants in a recent conference held by the NIH indicated that standardization of performing and reporting acupuncture neuroimaging results and data sharing between laboratories must be improved.

SUMMARY

Physiological and imaging studies are providing insight into the neurophysiological mechanism of acupuncture analgesia. Recent data suggest that acupuncture triggers a sequence of events involving the release of endogenous opioid-like substances, including enkephalin, β-endorphin, and endomorphin, that modulate pain signals processed along the pathway. Imaging studies demonstrate that the limbic system plays an important role in acupuncture-induced analgesia, as summarized in Table 1 and Figure 5. Future studies will continue to enhance our insight into the mechanism of this ancient analgesic modality.

REFERENCES

4. NIH consensus development panel on acupuncture. JAMA 1998;280:18–24


Acupuncture Analgesia: II. Clinical Considerations

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Paul F. White, PhD, MD, FANZCA‡

BACKGROUND: Acupuncture and related percutaneous neuromodulation therapies can be used to treat patients with both acute and chronic pain. In this review, we critically examined peer-reviewed clinical studies evaluating the analgesic properties of acupuncture modalities.

METHODS: Using Ovid® and published medical databases, we examined prospective, randomized, sham-controlled clinical investigations involving the use of acupuncture and related forms of acustimulation for the management of pain. Case reports, case series, and cohort studies were not included in this analysis.

RESULTS: Peer-reviewed literature suggests that acupuncture and other forms of acustimulation are effective in the short-term management of low back pain, neck pain, and osteoarthritis involving the knee. However, the literature also suggests that short-term treatment with acupuncture does not result in long-term benefits. Data regarding the efficacy of acupuncture for dental pain, colonoscopy pain, and intraoperative analgesia are inconclusive. Studies describing the use of acupuncture during labor suggest that it may be useful during the early stages, but not throughout the entire course of labor. Finally, the effects of acupuncture on postoperative pain are inconclusive and are dependent on the timing of the intervention and the patient’s level of consciousness.

CONCLUSIONS: Current data regarding the clinical efficacy of acupuncture and related techniques suggest that the benefits are short-lasting. There remains a need for well designed, sham-controlled clinical trials to evaluate the effect of these modalities on clinically relevant outcome measures such as resumption of daily normal activities when used in the management of acute and chronic pain syndromes.

(Anesth Analg 2008;106:611–21)

Acupuncture and related techniques are nonpharmacologic modalities that are based on classical teachings in Chinese medicine and can be used for the management of pain. Although a National Institute of Health consensus statement published in 1998¹ indicated that acupuncture might be useful for the treatment of certain pain conditions, the recent scientific evidence supporting the use of acupuncture and related forms of acustimulation for the relief of acute and chronic pain has not been critically reviewed.

Although many early clinical studies describing the potential clinical usefulness of acupuncture were poorly controlled,¹ more recent studies²–⁴ suggest that acupuncture analgesia can be used as an adjuvant in the treatment of conditions such as low back pain (LBP), osteoarthritis (OA) of the knee and neck pain.

In the first review article in this series, we addressed the issue of underlying mechanisms of acupuncture analgesia.⁵ In this article, we critically evaluate the clinical evidence regarding the use of acupuncture and its variants in both the short- and long-term management of specific pain syndromes. The focus of this article is on prospectively randomized, sham-controlled clinical trials published in the peer-reviewed medical literature after the consensus panel review of 1998.¹ Anecdotal case reports, case-series, and cohort studies were excluded from this review. We have chosen to focus on sham-controlled trials because of the potential bias for patients and investigators in uncontrolled clinical trials. Indeed, sham-control design is mandatory in acupuncture research to prevent the introduction of reporting bias. This calls for the introduction of an acupuncture-like intervention (e.g., needling to a nonacupuncture point, or a spurious stimulation at established acupuncture points).
METHODS

We evaluated studies involving clinical analgesic effects of specific forms of acustimulation that include not only traditional Chinese manual acupuncture, acupressure, and electroacupuncture (EA), but also auricular acupuncture and related electrical nerve stimulation techniques such as transcutaneous electrical acupuncture point stimulation (TEAS), percutaneous electrical nerve stimulation (PENS), percutaneous neuromodulation therapy (PNT), and transcutaneous electrical nerve stimulation (TENS). In reviewing the peer-reviewed literature, all these forms of acustimulation appear to have very similar clinical outcomes. Classic manual acupuncture consists of inserting and manipulating needles into the various acupuncture points whereas acupressure is a technique that uses pressure to stimulate these same acupuncture points. EA is a technique that applies small electrical currents to needles inserted at acupuncture points, whereas TEAS consists of applying an electrical current to cutaneous electrodes that have been placed at acupuncture points. Auricular acupuncture is based on the concept that different ear points represent different organs of the body and includes administration of pressure, needle, or electrical stimulation to specific points on the ear. In contrast, TENS and PENS are based on sending an electrical current either through cutaneous electrode patches (TENS) or acupuncture-like needles to the nerve serving the painful area (PENS). Finally, PNT is a variant of PENS that differs only with respect to the length of needle.

The oldest acustimulation, traditional Chinese manual acupuncture, consists of inserting acupuncture needles into acupuncture points along traditional acupuncture meridians and applying manipulations, e.g., twist, thrust, push and pull until the patient and acupuncturist both experience the “De Qi” sensation. This sensation is frequently described by patients as soreness, numbness, ache, fullness, or warm sensation and by acupuncturists as the feeling of the needle getting caught. Wang et al. suggest that manipulation of the acupuncture needle activates various afferent fibers (type II, III, and IV) and that this activation results in the De Qi sensation. For example, type II afferent fibers (A-β fibers) are responsible for the sensation of numbness/pressure, type III fibers (A-δ fibers) are responsible for a stinging sensation, and type IV fibers (C-fibers) are responsible for a slow diffusion, and aching/nagging sensation. Studies by Langevin et al. indicate that the “needle grasp” sensation experienced by acupuncturists during manipulation is due to the mechanical coupling between the needle and the connective tissue with winding of tissue around the needle during needle rotation."In contrast, electrical acupuncture modalities consist of applying different frequencies of electrical stimulation to acupuncture needles inserted at the traditional acupuncture points. Interestingly, a study has shown that 70% of local trigger points correspond to the traditional acupuncture points9 and that the analgesic effect through electrical acupuncture point stimulation is similar to the electrical stimulation at the corresponding dermatomal levels or peripheral nerve. Alternative medical therapies, such as acupuncture and related forms of acustimulation, will likely assume an increasing role in western medicine as scientific evidence supporting these therapies becomes available to practitioners.12

In this article, we will discuss evidence supporting the use of acustimulation in chronic LB and neck pain, OA involving the knees, dental pain, surgical and procedure-related pain, acute postoperative pain, and labor pain.

Chronic LBP

Early clinical studies and meta-analysis indicating that acupuncture was not effective for the treatment for chronic LBPD13–15 suffered from methodologic limitations such as inadequate sample sizes, problematic study designs, and the use of invalid outcome measures. In 2001, Carlsson and Sjolund conducted a sham randomized controlled trial (RCT) study among men and women suffering from chronic LB and found that both manual and EA were superior to sham electrical stimulation in reducing pain and improving sleep patterns, activity repertoire, and analgesic consumption at 4–6 mo postintervention.16 Interestingly, these positive findings were limited to women subjects. In 2002, Leibing et al. published a RCT involving 131 patients who suffered from LBP and who had normal neurologic examinations for at least 6 mo before their enrollment in the study.17 These investigators found that an intervention consisting of 26 sessions of combined ear and body manual acupuncture and physical therapy was superior to an intervention that consisted of 26 sessions of standard physical therapy alone for reducing pain, disability, and psychological distress for the first 3 mo of treatment. The beneficial effects of acupuncture were not lasting and at 9 mo after the last intervention there were no differences between the two study groups. A more recent RCT found that the combination of true acupuncture with conservative orthopedic treatment was superior to sham acupuncture combined with conservative orthopedic treatment or conservative orthopedic treatment alone.18 However, the beneficial effects lasted only 3 mo.

Several studies have also compared the efficacy of alternative electrostimulation techniques (e.g., PENS, PNT) for the treatment of LB. For example, Ghoname19 found that PENS was more effective than TENS or exercise therapy in providing short-term pain relief and improved physical function in patients with LB caused by degenerative disk disease. In a follow-up study, these investigators reported that PENS analgesic effects resulting from alternating electrical stimulation at frequencies of 15 and 30 Hz were superior to
analgesic effects resulting from isolated lower (4 Hz) or higher (100 Hz) frequency stimulation. These investigators also studied the effect of the duration of alternating 15 Hz/30 Hz PENS stimulation. They found that analgesic effects resulting from 30 min of stimulation were superior to analgesic effects obtained after 15 min stimulation. However, prolonging the stimulation to 45 min failed to improve the analgesic response. The investigators concluded that there is no additional prolongation of the analgesic effect once the alternated 15 Hz/30 Hz PENS was given for longer than 30 min.

Yokoyama et al. performed a RCT to compare the effects of 8 wk of PENS and TENS therapy for the treatment of long-term pain relief in patients with chronic LBP. They found that, although PENS is more effective than TENS for chronic LBP, the analgesic effect was only sustained for 1 mo posttreatment. The investigators concluded that to sustain the analgesic effect PENS therapy should be continued. Sator-Katzenschlager et al. explored the effectiveness of semi-permanent press needle auricular acupuncture compared with electrical auricular acupuncture as a treatment for LBP. The investigators found that electrical auricular acupuncture is superior to semi-permanent press needle acupuncture in decreasing the severity of LBP and improving psychological well being, activity, and sleep at 3 mo after treatment. Similarly, Meng et al. found that EA is superior to standard therapy such as nonsteroidal antiinflammatory drug, muscle relaxants, paracetamol, and back exercises in elderly patients who suffer from LBP. Since the above long-term acupuncture studies did not have a sham-control group, one can only conclude that there are some differences in the effect of analgesia among various stimulation techniques and treatment modalities.

In conclusion, although data from sham-controlled clinical studies indicate that acupuncture and alternative forms of electrostimulations (PENS and PNT) can serve as a short-term adjunct treatment for LBP management, no study has proven any long-term benefit of acupuncture and/or any other related interventions as a treatment for LBP. This lack of long-term benefit may be related to quick degradation of acupuncture-induced endogenous endorphins. Future studies should include sham-control groups and focus on specific target patient population, types and location of LBP. These studies should also focus on clinically relevant outcome measures such as activity of daily living and functionality (e.g., return to work).

**Chronic Neck Pain**

The design of many of the clinical studies focusing on the therapeutic effect of acupuncture and other forms of acustimulation on chronic neck pain is similar to that of LBP. Irnich et al. conducted a sham-controlled RCT that compared acupuncture with massage therapy for treatment of chronic neck pain. The investigators found that although true acupuncture was superior to massage therapy it was not superior to sham acupuncture. After the publication of this study in the British Medical Journal, a letter to the editor by Vickers suggested that data analysis of the study was not acceptable and that the original data had to be reanalyzed. Indeed, after reanalysis of the data, Vickers suggested that acupuncture was superior as compared to massage and sham therapies as a short-term treatment for chronic neck pain. Vickers and Irnich next collaborated in a sham-RCT study that compared acupuncture needle placement at acupuncture points to local trigger points and to sham laser acupuncture. They found that stimulation at acupuncture points is superior to both direct needling of local trigger points and laser sham acupuncture for improving motion-related pain and range of movement in chronic neck pain patients. This study examined, however, only the immediate effects of acupuncture on neck pain (15–30 min). A similar study was conducted using true and sham acupuncture needling applied directly to local trigger points in patients who suffered from chronic neck and shoulder pain. The investigators found that although acupuncture provided greater immediate relief for the neck and shoulder pain there were no long-term benefits. White et al. conducted a sham-controlled crossover study to explore whether the location of the PNT has an effect on the immediate analgesic responses in patients who suffer from chronic neck pain. These investigators found that local (versus remote) dermatomal needling produced greater improvement in the analgesic response, as well as both physical and mental performance, as assessed by a well-validated functional inventory, the SF-36.

Sator-Katzenschlager et al. compared the efficacy of six weekly treatments of manual and auricular EA for the treatment of chronic neck pain (Fig. 1). The investigators found that auricular EA is superior to manual auricular acupuncture in reducing the severity of pain, analgesic consumption, and return to full-time employment. In a large-scale trial that was conducted in the United Kingdom, patients were randomized to receive either TEAS or sham-TEAS. Eight treatments were administered over a 4-wk period and outcome assessments included neck pain, the neck disability index, the SF-36, and analgesic consumption. This study found that patients in the TEAS group reported significantly less pain when compared with patients in the sham-TEAS group. However, neck disability index and SF-36 scores did not differ significantly between groups. Finally, a small-scale sham-RCT was conducted with 24 subjects who suffered from chronic neck and shoulder pain. Subjects were randomized to receive either 10 acupuncture or sham-acupuncture treatments combined with daily acupressure at acupuncture points or at sham points over a 3–4 wk period. After this very intensive regimen, the investigators found that at the 6 mo and 3 yr
follow-up evaluations patients in the acupuncture group had better sleep quality, less anxiety and pain, less depression, and a higher satisfaction with life when compared with patients in the sham group. In contrast to the above studies, a crossover study by Zhu and Polus indicated that there are no differences in either subjective or objective measures between true and sham acupuncture treatments for chronic neck pain. Analogous to the studies in patients with chronic LBP, studies indicate that PENS and PNT are effective short-term treatments for chronic neck pain. Preliminary data suggest that acustimulation may establish the efficacy of acupuncture as a long-term treatment for chronic neck pain. We submit that additional studies are needed to determine the duration and strength of pain relief compared with established therapies and the underlying physiologic mechanism of acupuncture-induced analgesia in chronic neck pain.

**OA of the Knee**

Although acupuncture is commonly used as a treatment for OA of the knee, a systematic review published in 2001 found inconsistent results and insufficient evidence to determine whether acupuncture is superior to sham treatment. However, Berman et al. investigated the efficacy of acupuncture as an adjunctive therapy in elderly patients suffering from OA of the knee using a randomized crossover study design. These investigators found that patients randomized to acupuncture treatments had improved on both McMaster University’s OA index and Lequesne’s indices at 4 and 8 wk. The same research team then conducted a large-scale sham-controlled RCT that included 570 patients that were randomized to receive acupuncture treatment, sham treatment, or an educational intervention over a 6-mo period. The research team found that patients in the acupuncture group experienced significantly greater improvement than the sham group in both McMaster University’s OA index function and pain scores. A sham-controlled RCT published in *Lancet* randomized patients with OA of the knee to receive 8 wk of acupuncture, sham, or waiting list control. The study found that patients in the acupuncture group experienced improved joint movement and significantly less pain. However, a follow-up at 1 yr revealed no differences among the various study groups.

We conclude that the use of acupuncture stimulation is an effective short-term treatment of OA of the knee. Unfortunately, long-term benefits from acupuncture treatment have not been demonstrated.

**Dental-Related Pain**

A systemic review published in 1998 in the *British Dental Journal* suggested that acupuncture could alleviate pain after dental procedures. In 1999, a randomized, double-blind, placebo-controlled trial conducted by Lao et al. reported that the average pain-free postoperative time and time to requested pain medication was longer in patients who received true versus sham acupuncture during wisdom tooth extraction. Kitade and Ohyabu performed a study to examine patients who underwent mandibular wisdom tooth extraction using local anesthesia versus a combination of local anesthesia and low-frequency electrical acupuncture at bilateral LI4 (“He Gu” the 4th acupuncture point along the large intestine meridian), unilateral at ST6 (“Jia Che” the 6th acupuncture point along the stomach meridian) and ST7 (Xia Guan the 7th acupuncture point along the stomach meridian).

*Figure 1. A, acupuncture points are indicated by bullets and numbered according to the nomenclature of Nogier: cervical spine, shen men, and cushion. B, The electrical point stimulation device P-STIM™. Reproduced with permission from Sator-Katzenschlager S, Szeles J, Scharbert G, Michalek-Sauberer A, Kober A, Heinze G, Kozek-Langenecker S. Anesth Analg 2003; 97:1469–73, © Lippincott Williams & Wilkins.*
acupoints (ipsilateral to the surgical side). The investigators found that EA significantly decreased the magnitude of postoperative pain. A large-scale study by Bausell et al.\textsuperscript{44} was designed to explore the effect of “expectancy” in acupuncture analgesia on postprocedural dental pain. The investigators found that, although there was no statistically significant analgesic effect between the acupuncture and placebo groups, participants who believed they received “real” acupuncture reported significantly less pain than those who believed they had received a placebo.

We conclude that data regarding the use of acupuncture analgesia for the management of acute dental pain is inconclusive and that future studies should consider the issue of “expectancy effect.”

**Procedural Analgesia**

Acupuncture and related techniques have been used during medical procedures, such as colonoscopy. Wang et al.\textsuperscript{45} demonstrated that pain, serum β-endorphins, epinephrine, norepinephrine, and dopamine levels were similar between patients who received EA (ST36-Zusanli, ST37-Shangjuxu; the 36th and 37th acupuncture points along the stomach meridian, auricular Shenmen point) and patients who received meperidine during colonoscopy procedures. These investigators also found that patients receiving EA had fewer side effects such as dizziness. Since these investigators did not include a sham-control group, their findings should be interpreted cautiously. Fanti et al.\textsuperscript{46} conducted a sham-RCT to evaluate the analgesic effects of EA in a group of patients who were undergoing colonoscopy procedures. Patients in both the acupuncture and sham groups received the same frequency (100 Hz) of stimulation for the 20 min before the procedure and throughout the duration of the procedure. The investigators found that patients in the acupuncture group reported nonsignificantly reduced pain during the procedures.

Therefore, currently available data do not support the use of acupuncture as an analgesic adjuvant during colonoscopy.

**Surgical Anesthetic and Anecdotal Analgesic—Sparing Effects**

Anecdotal reports from China indicate that acupuncture can be used successfully as a sole anesthetic in a variety of surgical procedures such as open-heart surgery.\textsuperscript{47} However, whether acupuncture can be used as a sole anesthetic or as an adjunct to local and general anesthesia in the Western world remains to be determined. Schaer\textsuperscript{48} conducted a study in which women undergoing gynecological procedures that required general anesthesia were randomized to receive fentanyl or EA for intraoperative analgesia. The investigator found that EA was as effective as 0.27 μg/kg of fentanyl given IV every 10 min. Greif et al.\textsuperscript{49} performed electrical stimulation at the lateralization-control point near the ear tragus and reported that this intervention significantly decreased the desflurane anesthetic requirements (approximately 25%). Similarly, Taguchi et al.\textsuperscript{50} who applied auricular acupuncture stimulation at Shenmen, thalamus, tranquilizer, and master cerebral points also observed a similar anesthetic-sparing effect.

In contrast, Sim et al.\textsuperscript{51} conducted a sham-controlled RCT study of EA in a group of women scheduled for lower abdominal surgery. The women were randomized to receive preoperative EA or sham EA, or postoperative EA at ST36 and PC6. The investigators found no difference when preoperative EA was compared with preoperative sham EA; more importantly, postoperative patient-controlled analgesia morphine consumption was not different among the three treatment groups. Similarly, Morioka et al.\textsuperscript{52} found that EA failed to decrease desflurane anesthetic requirements, and Kvorning et al.\textsuperscript{53} found that EA actually increased sevoflurane anesthetic requirements.

Based on these contradictory data, it is reasonable to conclude that the effect of intraoperative acupuncture analgesia remains controversial. In future studies, it is also necessary to standardize the type and depth of anesthesia and opioid analgesic usage, as well as the duration of stimulation. These conflicting results can be partially explained by suppression of acupuncture-induced blood oxygen level-dependent (BOLD) signals observed under general anesthesia.\textsuperscript{54} Acupuncture-induced BOLD signals are the magnetic signals generated...
by the ratio of oxyhemoglobin and deoxyhemoglobin in the areas of the brain where there are hemodynamic changes related to acupuncture stimulation. In other words, acupuncture-induced BOLD signals are an indirect measure of neuronal activities at the regions of the brain affected by the acupuncture stimulation.

Acute Postoperative Pain

Manual Acupuncture Techniques

In a sham-controlled RCT, Kotani et al. applied intradermal needles to “Back Shu” acupoints in a group of patients who were scheduled to undergo major abdominal procedures. These acupuncture needles were inserted 2 h before induction of anesthesia and retained in place for 48 h postoperatively. The investigators found that patients in the acupuncture group reported a significant reduction in postoperative pain and analgesic requirements and postoperative nausea and vomiting compared to the sham group. Usichenko et al. examined the analgesic effects of auricular acupuncture in a group of patients who underwent total hip arthroplasty. Sixty-one patients, who were scheduled to have total hip arthroplasty, were randomized to receive either auricular acupuncture or sham (auricular) acupuncture perioperatively. The acupuncture semipermanent press needles were placed the evening before surgery and retained for 36 h postoperatively. The investigators found that analgesic consumption during the first 36 h postoperatively was lower in the auricular acupuncture group compared with the sham group. In contrast to the above positive studies, Gupta et al. conducted a sham-controlled RCT to evaluate the effect of intraoperative acupuncture intervention on the analgesic requirement after knee arthroscopy. The investigators found that analgesic consumption during the first 36 h postoperatively was lower in the auricular acupuncture group compared with the sham group. In contrast to the above positive studies, Gupta et al. conducted a sham-controlled RCT to evaluate the effect of intraoperative acupuncture intervention on the analgesic requirement after knee arthroscopy. The investigators concluded that acupuncture is effective in decreasing the severity of postoperative pain, only when the acupuncture stimulation was performed before induction of anesthesia and/or during the postoperative period. In contrast, acupuncture administered while the patient was under general anesthesia was found to be ineffective in decreasing postoperative analgesic requirement.

Electroacustimulation

In 1989, Christensen et al. conducted a RCT involving 20 healthy women who underwent gynecological surgery and received either EA or no treatment (control). The intervention was administered while these women were emerging from general (volatile) anesthesia. Reprinted by permission from Chen L, Tang J, White PF. Anesth Analg 1998;87:1129–34, © Lippincott Williams & Wilkins.
anesthesia but received 70% nitrous oxide to block recall of the intervention. Postoperatively, the investigators found that patients who received EA consumed significantly less (40%) pethidine in the postanesthesia care unit when compared with the control group. In a follow-up RCT, these researchers administered continuous EA from the preoperative period throughout the intraoperative period.61 In contrast to their previous findings, the investigators found no differences in the postoperative analgesic consumption between the acupuncture and control groups.61 This reported inconsistency may have been a result of the development of tolerance to prolonged acupuncture stimulation62 and/or a direct suppression of acupuncture-related BOLD signals by general anesthesia.54 These data are consistent with studies examining the efficacy of acupoint stimulation for the prevention of postoperative nausea and vomiting. For example, White et al.63 found that acupoint stimulation was only effective when administered after surgery.

In 1997, Wang et al.59 conducted a sham-controlled RCT evaluating the analgesic effect of postoperative TEAS in patients undergoing lower abdominal surgery (Fig. 2). Following a standardized anesthetic protocol, TEAS was applied either to acupuncture points or the para-incisional dermatomes, with the intensity of the electrical stimulation delivered high (9–12 mA) or low (4–5 mA) level. The investigators found that TEAS treatment of these locations resulted in a 30%–35% reduction in the postoperative opioid analgesic requirements. They also found that high-intensity TEAS was more effective in decreasing postoperative analgesic requirement than low-intensity anesthesia.

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<th>Acupuncture Points Used for Various Acustimulation Techniques in the Management of Acute and Chronic Pain Syndrome</th>
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<td>Acupuncture points</td>
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<td>Lower back pain</td>
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<td>Body acupuncture</td>
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<td>Large intestine meridian</td>
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<td>Urinary bladder meridian</td>
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<td>Governing vessel meridian</td>
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<tr>
<td>Spleen meridian</td>
</tr>
<tr>
<td>Ear acupuncture</td>
</tr>
<tr>
<td>Os sacrum</td>
</tr>
<tr>
<td>Parasympathicus</td>
</tr>
<tr>
<td>Nervus ischiadicus</td>
</tr>
<tr>
<td>Lumbar sacrum</td>
</tr>
<tr>
<td>Shenmen</td>
</tr>
<tr>
<td>Kidney</td>
</tr>
<tr>
<td>Lumbar spine</td>
</tr>
<tr>
<td>Neck pain</td>
</tr>
<tr>
<td>Body acupuncture</td>
</tr>
<tr>
<td>Small intestine meridian</td>
</tr>
<tr>
<td>Kidney meridian</td>
</tr>
<tr>
<td>Lung meridian</td>
</tr>
<tr>
<td>Urinary bladder meridian</td>
</tr>
<tr>
<td>Conception vessel meridian</td>
</tr>
<tr>
<td>Governing vessel meridian</td>
</tr>
<tr>
<td>Large intestine meridian</td>
</tr>
<tr>
<td>Ear acupuncture</td>
</tr>
<tr>
<td>Cervical spine</td>
</tr>
<tr>
<td>Stellate ganglion</td>
</tr>
<tr>
<td>Osteoarthritis of the knee</td>
</tr>
<tr>
<td>Body acupuncture</td>
</tr>
<tr>
<td>Gallbladder meridian</td>
</tr>
<tr>
<td>Spleen meridian</td>
</tr>
<tr>
<td>Stomach meridian</td>
</tr>
<tr>
<td>Kidney meridian</td>
</tr>
<tr>
<td>Bladder meridian</td>
</tr>
<tr>
<td>Colonoscopy</td>
</tr>
<tr>
<td>Body acupuncture</td>
</tr>
<tr>
<td>Large intestine meridian</td>
</tr>
<tr>
<td>Stomach meridian</td>
</tr>
<tr>
<td>Spleen meridian</td>
</tr>
<tr>
<td>Surgical analgesia</td>
</tr>
<tr>
<td>Body acupuncture</td>
</tr>
<tr>
<td>Stomach meridian</td>
</tr>
<tr>
<td>Spleen meridian</td>
</tr>
<tr>
<td>Large intestine meridian</td>
</tr>
<tr>
<td>Pericardium meridian</td>
</tr>
<tr>
<td>Liver meridian</td>
</tr>
<tr>
<td>Urinary bladder meridian</td>
</tr>
<tr>
<td>Ear acupuncture</td>
</tr>
<tr>
<td>Shenmen</td>
</tr>
<tr>
<td>Thalamus</td>
</tr>
<tr>
<td>Tranquilizer point</td>
</tr>
<tr>
<td>Master cerebral</td>
</tr>
</tbody>
</table>

| Table 1. | Acupuncture points | References |
| Postoperative pain |
| Body acupuncture |
| Stomach meridian | 34, 36 | 53, 56, 57 |
| Large intestine meridian | 4 | 53, 54 |
| Governing vessel meridian | 2, 4 | 54 |
| Urinary bladder meridian | 18–26 and 32 | 51, 54 |
| Spleen meridian | 6, 9, 10 | 53, 54 |
| Ear acupuncture |
| Hip joint | 52 |
| Shenmen | 52 |
| Lung | 52 |
| Thalamus | 52 |
| Labor pain |
| Body acupuncture |
| Lung meridian | 7 | 60 |
| Gall bladder meridian | 25, 26, 27, 28, 29 | 60 |
| Urinary bladder meridian | 25–36, 54, 67 | 60, 61 |
| Conception vessel meridian | 2, 3 | 60 |
| Large intestine meridian | 4 | 60, 61 |
| Spleen meridian | 6 | 60, 62 |
TEAS. Chen et al.11 conducted a similar study with surgical patients randomized to receive TENS at one of three locations: an acupuncture point, a nonacupuncture point, or at the dermatome corresponding to the surgical incision (Fig. 3). They found that both TENS at the acupuncture point and TENS at paraincisional dermatomes were effective in producing a similar analgesic-sparing effect after surgery. Importantly, simultaneous stimulation at both acupoints and dermatomes resulted in additive opioid-sparing effects. Lin et al.60 performed a large scale RCT to examine the effects of various frequencies of preoperative EA on postoperative pain and opioid-related side effects. Analogous to previous investigations,11,60 they found that the postoperative analgesic effect is positively correlated to the frequency of the electrical stimulation. That is, 100 Hz of EA resulted in less analgesic consumption in the first 24 h postoperatively.

In conclusion, acupuncture is effective as an adjunctive treatment for acute postoperative analgesia if administered to surgical patients in the postoperative period. Future studies should examine whether the efficacy of EA and related forms of acustimulation is influenced by the depth of anesthesia, types of anesthetics (i.e., IV versus volatile), and different states of anesthesia or types of anesthetics. It also seems that the analgesic effect of electro-analgesia is affected by the duration, amplitude, and frequencies of stimulation. Location of electrode placement plays a less significant role in the analgesic effect as long as the placement of electrodes is either at an appropriate acupuncture point or at the peripheral nerves corresponding to the surgical incision.11

**Labor Analgesia**

Ramnero et al.64 conducted a nonblinded RCT study to evaluate the efficacy of acupuncture as an analgesic adjuvant during labor. These investigators found a decreased requirement for meperidine in the acupuncture group compared with a control group with the same parity. Chung et al.65 conducted a sham-controlled RCT study to determine the effect of acupressure on labor pain and uterine contractions during the first stage of labor (Fig. 4). These investigators found that during the first stage of labor the patients who received acupressure reported significantly less labor pain compared to patients who received sham or no treatment. Moreover, there was no significant difference in uterine contractions during the first stage of labor among the three groups. Finally, Lee et al.66 performed a sham-controlled RCT to evaluate the analgesic effects of acupressure on labor pain and time to delivery. These investigators reported that labor pain score during the first hour after delivery was significantly lower in the acupuncture group compared to the control group.

### Table 2. Summary of the Evidence Supporting the Use of Acupuncture and Related Forms of Acustimulation in the Management of Chronic Pain Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Interventions</th>
<th>Reference (1st author/no.)</th>
<th>No. of subjects (N)</th>
<th>Postintervention (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low back pain</td>
<td>Acupuncture</td>
<td>Carlsson/16</td>
<td>50</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Leibing/17</td>
<td>133</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Molsberger/18</td>
<td>124</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>PENS</td>
<td>Ghonname/19</td>
<td>62</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td></td>
<td>PENS</td>
<td>Ghonmae/20</td>
<td>68</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>PENS</td>
<td>Hamza/21</td>
<td>75</td>
<td>&lt;0.001 for 30 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and 45 min</td>
</tr>
<tr>
<td></td>
<td>PENS vs. TENS</td>
<td>Yokoyama/22</td>
<td>60</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Sato-Katzenschlager/23</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Meng/24</td>
<td>55</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Irnich/Vicker reanalysis/27,28</td>
<td>177</td>
<td>0.031</td>
</tr>
<tr>
<td>Neck pain</td>
<td>Acupuncture</td>
<td>Irnich/29</td>
<td>36</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Nabetta/30</td>
<td>34</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>PNT</td>
<td>White/31</td>
<td>68</td>
<td>&lt;0.001 for local</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dermatome</td>
</tr>
<tr>
<td></td>
<td>Auricular Acupuncture</td>
<td>Sato-Katzenschlager/32</td>
<td>21</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>White/33</td>
<td>135</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Acupuncture +</td>
<td>He/34</td>
<td>24</td>
<td>&lt;0.04</td>
</tr>
<tr>
<td></td>
<td>pressure</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Osteoarthritis of the knee</td>
<td>Acupuncture</td>
<td>Zhu/35</td>
<td>29</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Gaw/36</td>
<td>40</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Berman/38</td>
<td>73</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Berman/39</td>
<td>570</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Witt/40</td>
<td>294</td>
<td>0.063</td>
</tr>
</tbody>
</table>

**PENS** = percutaneous electrical nerve stimulation; **TENS** = transcutaneous electrical nerve stimulation; **PNT** = percutaneous neuromodulation therapy.

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the intervention was lower and the total labor time (i.e., delivery time) was significantly shorter in the acupressure versus sham-control group. Therefore, available data indicate that acupuncture and related techniques may be effective for the early stage of labor. However, more data are needed to establish the effectiveness of acustimulation techniques during the entire labor process.

**SUMMARY**

This article summarizes the current peer-reviewed literature related to the analgesic effect of various forms of acustimulation. Indeed, acupuncture appears to be most effective for short-term management of back pain, neck pain and OA involving the knee. Data regarding the efficacy of acupuncture for dental pain, perioperative pain and colonoscopy pain are inconclusive. Although there are only a few studies examining the efficacy of acupuncture during labor, it seems that acupuncture and related techniques are effective only for stage I labor.*

Any discussion that involves acupuncture-related research is not complete without addressing some of the methodologic issues in this area. Similar to other clinical studies, some acupuncture studies are hindered by inappropriate sample size, confounding variables, poorly defined outcomes, invalidated outcome measures, and inadequate follow-up. Acupuncture research does, however, present additional hindrances such as acupuncturist positive expectancy bias. Although the use of sham is widely recommended in the literature, this technique is not without problems. Insertion of a needle in a nonacupuncture point may result in unexpected physiological results, such as changes in pain thresholds and unintended release of endorphins. The development of a sham-needle may be a solution to the above issue; however, it is difficult to blind the patient and acupuncturist because the presentation of how an acupuncture needle is secured into the acupuncture point and sensation of acustimulation are different from true acupuncture stimulation. The quest for a matching sham control, one that is inert and identical in appearance and sensation is continuing. Also, the use of subjective De Qi sensation experienced by acupuncturists and patients poses a significant challenge for researchers. There remains a need for well-designed, sham-controlled clinical trials to evaluate the role of acupuncture and related

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*We refer the reader to www.yinyanghouse.com for an anatomical drawing of the locations of specific acupuncture points. The reader should note that acupuncture points used in the different studies described in this review appear in Table 1 and therapeutic effects of acupuncture analgesia for various acute and chronic clinical entities discussed in this paper are summarized in Tables 2 and 3.

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**Table 3. Summary of the Studies for Acute Conditions**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Interventions</th>
<th>Reference (1st author/no.)</th>
<th>No of subjects (N)</th>
<th>Postintervention (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental analgesia</td>
<td>Acupuncture</td>
<td>Lao/42</td>
<td>39</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Kitade/43</td>
<td>44</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Colonoscopy</td>
<td>Electroacupuncture</td>
<td>Fant/46</td>
<td>30</td>
<td>0.01</td>
</tr>
<tr>
<td>Surgical analgesia</td>
<td>Electroacupuncture</td>
<td>Greif/49</td>
<td>20</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Taguchi/50</td>
<td>10</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Postoperative 6–12 h, P = 0.015; total 24 h, P &gt; 0.05</td>
</tr>
<tr>
<td>Postoperative pain</td>
<td>Electroacupuncture</td>
<td>Morioka/52</td>
<td>14</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Korning/53</td>
<td>46</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Taguchi/55</td>
<td>175</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Auricular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Gupta/57</td>
<td>42</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Christensen/58</td>
<td>20</td>
<td>2 h postoperative, P = 0.007; 6 h postoperative, P = 0.058</td>
</tr>
<tr>
<td>TAES</td>
<td>Wang/59</td>
<td>101</td>
<td>24 h postoperative, P &lt; 0.05 for low and high TAES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electroacupuncture</td>
<td>Lin/60</td>
<td>100</td>
<td>&lt;0.05 for first request of pain medicine, total analgesic requirement for the 24 h postoperative</td>
</tr>
<tr>
<td>Postoperative pain</td>
<td>Electroacupuncture</td>
<td>Christensen/61</td>
<td>50</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Ramnero/64</td>
<td>46</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Acupressure</td>
<td>Chung/65</td>
<td>127</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>Acupuncture</td>
<td>Lee/66</td>
<td>75</td>
<td>P = 0.021 for pain reduction, P = 0.006 for duration of labor</td>
</tr>
</tbody>
</table>

TAES = transcutaneous acupoint electrical stimulation.
acustimulation analgesic techniques in the management of acute and chronic pain syndromes. These future studies should also include outcome measures such as patient well-being and resumption of normal activities.

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Qi, Pneuma, Vitalism and Meridians

or

An Historical Understanding of Why Much Acupuncture Research is Incredible

by Sara Bayer, M.A., EAMP

Although the word “vitalism” can be found in written form in the English language only as early as 1822, according to the Oxford English Dictionary, the roots of the concept run back much further. By the 1800’s vitalism had come to mean “the doctrine and theory that the origin or phenomena of life are due to or produced by a vital principle, as distinct from a purely chemical or physical force.”¹ So defined, it represents a developed concept that as a badge of its development had acquired opposing concepts that began to fix its meaning. It developed proponents and opponents. Heated debate grew around it when it was perceived to be a movement that refuted developing scientific reductionist thought. I am fairly sure it cannot qualify as a school of thought, but rather as a strand of thought embedded in the development of first philosophy and then science. As we shall see, Chinese medicine and in particular the popular understanding of the concept of Qi, is now involved in the Western discourse about vitalism.

Aristotle is considered by some to have been a vitalist philosopher, due to his view of the soul as an essential principle in an organism, related to the body by the entelechy or “indwelling purposiveness.”² He is also considered a vitalist because of his assertion that in human reproduction the male contributed non-material form or principle. The appearance of form was from some inherent potential, no matter what was being formed. Interestingly, Aristotle is also considered to be a father of science and of mechanistic
biological views because of his close observations of nature. Thus in recent time he has been used in support of both sides of the debate between vitalists and mechanists. In his own time the debate did not yet exist – the science within which the argument itself began did not yet exist.

There were other concepts in ancient Greek medicine that resonate with the idea of a vital animating force. One Aristotelian idea is that of the:

“driving force of the “innate heat,” which was a form of energy generated by the heart, and which in turn generated the humors… “Innate heat” was thus the essential ingredient of man’s composition. It was part of Nature’s healing power, the force that acted both to maintain equilibrium and to restore it when it was lost.”

Later Galen attributed “innate heat” to the liver.

Another Greek idea was the concept of pneuma. In the early Greek medicine of Galen pneuma was poorly defined, having no substance, but said to be what made living beings alive and was absent in inanimate objects. It did not function precisely as air, though some scholars translate it that way. It was said to flow in the arteries as blood was said to flow in the veins, thus bringing to life all the parts of the body. What was theoretically involved in pneuma however was not oxygen, rather it was inspiration of what was known in Latin as anima (pneuma in Greek) – or spirit. This relationship of blood and spirit is reminiscent of the relationship between blood and Qi in Chinese medicine, though it differs in particulars.

It may be the Greeks perceived that something involving air was going on in the arteries but could not figure out oxygenation of blood. It is more likely that pneuma represents a bridge between magical and material thinking. This bridge lasted for centuries until the Englishman Harvey discredited the Galenic ideas of circulation
involving a vital force. Because of the enormity of Harvey’s discovery of dual pulmonary and peripheral circulation of blood, all of Galen’s ideas including the theoretical existence of a vital force, were basically discredited among medical philosophers. Harvey’s demonstration of blood circulation was supposedly the death blow to the doctrine of the ‘spirits.’

This “death blow” however turned out to be one in a succession of non-lethal blows dealt to an idea that persists in science until the present day. The idea of a vital force or immanence that drove growth and development, and sustained form and life, repeatedly stood up in a new battle after having been knocked down during a previous battle in the process of scientific discovery. The idea of a vital force began to fracture as certain aspects of it were discarded, leaving fragments that served the medical-theoretical or religious and political purposes of the time.

Several important European philosophers supported ideas in both the vitalist and the mechanist sides of the discussion, Descartes among them. In the 1600’s Descartes had to be careful to not debunk the idea of the soul as the idea of soul was essential to the power of the Church. It also appears he was a devout Roman Catholic and was able and willing to live with a mixture of mechanistic ideas and vitalist ideas when explaining the phenomena of life. He considered the pineal gland to be the seat of the soul and yet the body that it operated could also mechanistically react to physical stimulation separately. Newton had a similar view – that Nature was “a mechanical system, arranged by God.”

Another mixed thinker was Descartes’ contemporary, the Dutchman Van Helmont. He believed in the existence of a sensitive soul, believed muscles were nourished by vitalized blood, and also posited the idea of subordinated vitalistic forces
(archaei) that function during various stages of digestion and assimilation. These differentiated forces bring to mind the much earlier differentiated Qi of zang-fu of Chinese medicine. In Van Helmont they were suborned to the larger soul, essential to religious conformity of his time and place. In fact, the history of excellence in scientific thinking among non-atheists is a large and interesting historical subject that would bear addressing.

The tug of war between vitalistic ideas and mechanistic ideas over the centuries included debate between epigenesis (development by cell differentiation) and abiogenesis (spontaneous generation) in embryology and biology, the production of heat in physics, and evolution in biology and anthropology. The waxing and waning of the popularity of religion, due to economic and political forces, influenced the debate. Mechanistic thinking was popular during the French revolution with its general refutation of religion. Mechanism and materialism shared proponents. After the French revolution there was a resurge in the popularity of vitalistic thinking, partially to discredit the materialism characteristic of the revolution and associated with its social chaos. A similar tension developed in Russia with a strong communist influence against religion and for materialism, “consequently against non-deterministic and vitalistic movements…” The parts of the world with religious freedom and older sociopolitical institutions, were able to tolerate vitalistic thought streams.

More recently, increasing sophistication in the thought of physicists and biochemists also influenced the debate. As scientific investigation pushed the boundaries of mechanistic-materialistic thinking to more rarefied realms, theories sounding remarkably vitalistic began to manifest within the very scientific tradition that had earlier
resisted vitalistic generalities. In biology, the way in which DNA transmits and stores attributes of life, has been discussed with vitalistic language:

“…the structured order of subunits is the meaningful message, which can be transmitted immediately or stored in “printed” form. It was a great discovery, following the unraveling of the molecular structure of DNA, that nature uses the same method as human beings. This method ensures that the knowledge needed for the unique form of existence, organic life, can emerge in time and persist. Thus the quantum jump which separates the non-living world from the biosphere of the living is the creation of knowledge. In fact, there is no gap between the living and non-living. At least in theory, chemistry and physics are continued in the living forms: the same processes which are characteristic for, and take place in the living cell can be produced in test tubes in the chemist’s laboratory. The jump is not over a hiatus: it is not a linear advance, but a three-dimensional change leading to an entirely new dimension in the scheme of things.”

The scientists here are re-becoming philosophers. It is ironic that the ability to produce urea (an organic compound) from its chemical constituents, in a laboratory, had earlier been used as fuel against the vitalists in the early 1800’s. It had been thought that organic compounds could only be made in organisms by a vital force. The ability to create an organic compound in a lab was seen as disproving the existence of such a force.

It appears to me that the idea of some sort of vital force animating the physical world has persisted no matter how deeply we investigate the machinery of life. The debate about the correctness of this idea has actually been a motivating force in the development of scientific discovery. The development of scientific discovery has itself merely resulted in the use of more and more refined language to describe what may be a necessary thought form upon which to base further development. That thought form may well be the idea of a vital force, otherwise ineffable. On the other hand it may be that vitalist thinking persists in reaction to reductionist science’s lack of poetry in describing the beauty of the physical world. Or, perhaps people fear that respect for life will be damaged by over-mechanistic thinking – as it was damaged during communist and fascist
political movements. Thus, it may be that vitalism is an aesthetic or ethical, as well as a scientific impulse.

Whether scientific, ethical, philosophical, or aesthetic, the idea of vitalism is associated in popular thinking with traditional Chinese medicine. Reading on the website of the New England Society of Skeptics we find:

The concept of a “life energy” itself, however, is not a mere four centuries old. Many ancient cultures have had similar beliefs since recorded time. China’s version, chi or qi, is probably the most well known. It still has millions of faithful adherents. Traditional Chinese Medicine (TCM), itself at least 5,000 years old (Ivker, 1999), is a vast collection of folk-wisdom based on mystical thinking in which chi is one of the central concepts. Practitioners contend that “life-energy” courses through our bodies in pathways or channels called meridians (Homola, 99). These meridians branch off to all the major organs of our body. An inextricable part of the belief in chi is the concept of harmony or balance. All problems with life and health are directly related to an imbalance or interruption of these life-giving energies. Once harmony and balance is achieved, good health inevitably returns.

One of the modalities of TCM most familiar to western society is acupuncture in which needles are inserted into specific “acupuncture points” that are said to be located throughout the body. When performed properly it is claimed that this rebalances and stimulates the body’s pattern of life energy, restoring health and equilibrium in the patient.12

The author goes on to state that there is no scientific basis for the theories of Chinese medicine as he describes them. After including Chinese medicine among vitalistic systems, he states that all vitalistic ideas are pseudoscience and thus without merit. Ignoring his simplistic and erroneous concept of a continuous body of Chinese medical knowledge (over 5000 years old!), the question remains, what is the relationship of Chinese medicine to vitalism?

Much as Aristotle’s writings hold very early references to a vital force for Greek philosophy, so do the writings of Mencius, an early Confucian philosopher, hold very
early references to Qi. Much as Aristotle’s philosophical propositions were taken up by Greek medical thinkers in the effort to systematize and understand the physical body, so the concept of Qi was taken up by Chinese medical thinkers with a similar goal. To Mencius, a non-medical thinker, Qi was “that which fills the body”, and is difficult to explain.\textsuperscript{13} “Cultivating it one could effect the transformation of things in oneself, in society, and in the cosmos.”\textsuperscript{14} The whole universe was thought to be filled with Qi, only quite recently translated as matter-energy\textsuperscript{15}. This “matter-energy” could be cultivated inside a person. Neo-Confucians such as Zhang Zai added the concept of Qi being in a constant process of self-generating transformation. The concept of \textit{li} or rites was introduced.\textsuperscript{16} Rites and cultivation of one’s own Qi became the motivation for learning about nature. Observation of nature and categorization of natural phenomena, including medicinal herbs, was seen as practical knowledge that would help clarify the relationships within nature and benefit society. It was also the way by which health could be maintained.

In Chinese medicine the differentiation of Qi into types belonging to pathogens, the different organs, and various processes within the human body recalls the \textit{archaei} of Von Helmont. Thus, in both East and West there were early attempts to broadly name what it is that makes life. Thereafter, observation of nature was undertaken to differentiate the specific details of how life worked, in humans and non-humans. A difference is that in the East, Qi imbued \textit{everything} in nature. Animal and plant life forms were just a \textit{part} of nature. In the West, animal life forms, including man, were seen as alive while non-animal and non-plant forms were seen as not-alive. A rock could have Qi, but not \textit{pneuma}. As we saw from the DNA discussion above, the Chinese concept of the
continuity of all things, with no essential division between living things and non-living things, is fundamentally more sound, even scientifically speaking. They had a better hunch!

So, where does the equation of the old Greek idea of *pneuma* with Qi come from, in places such as the New England Society for Skeptics? I believe it comes from the work of early European interpreters of Chinese medicine such as George Soulie de Morant. He was born in the late 1800’s in Europe where the vitalism-mechanism engine continued to stir debate. He lived in China for twenty years, returning to France in 1917. His writings were published in the 1930’s through the 1950’s. “Neo-vitalism” or yet another revival of vitalism was beginning at the close of the 19th century. It was being revived because once again investigative science was pushing up against something it could not explain. This something was the development of a full human from an ovum. Embryology was thus a branch of science reviving vitalism in the early part of the 20th century. Dr. Hans Driesch published *History and Theory of Vitalism* in 1914 and a second edition was published in 1929. His “proofs” of vitalism, according to Wheeler, included the assertion that “no machine, however far it is pushed, can account for the origin from an ovary of single cells...a whole organism.” He attributed this capability to *entelechy* or “indwelling purposiveness.”

During the same time period, World Wars I and II devastated Europe, China and Russia were in revolution, and human life was squandered. Science was opening doors on life as with the discovery of antisepsis, and closing others, as with the inventions of tanks and machine guns. Into this conflicted mass of responses to life came George Soulie de Morant back from China. Because of the rarity of Europeans with any on-the-ground
experience of China, he was hugely influential as an interpreter of Chinese culture in the West. Because he studied and practiced acupuncture he was especially influential in how Chinese medicine came to be understood by Europeans. I believe his way of introducing Chinese medical systems to the west supported both sides of the vitalism-mechanism debate.

On one hand, he used the terminology of modern science to describe how acupuncture works. He built on the investigations of French and German doctors of the late 1700’s and early 1800’s century, who thought animal electricity was the “divine spark” that separated living organism from dead bodies.18 They learned about acupuncture from a Dutch surgeon returned from working for the Dutch East India Company in Peking. They combined acupuncture and electricity to treat dropsy with disastrous results and pain with less disastrous results.19 De Morant was the first to translate “Qi” as “energy” and he believed science would one day corroborate the translation. 20 On the other hand, he attributed disease to “moral and mental changes,” to imbalances that could be read in the pulses. These imbalances presaged actual disease, and acupuncture to him was best used as prevention. These ideas, more congruent with traditional Chinese medicine than notions of neuroanatomy, were unlikely to be accepted by the burgeoning reductionist scientists of the time but may have provided a sense of comfort to a tired public in need of miracles. Significantly but separately, they also probably reflected his experience of the effectiveness of acupuncture. De Morant was tying in to new-fangled ideas of electricity and old-fangled ideas of life force. I believe he was projecting ideas from European history of science and philosophy onto Chinese medicine for purposes of its importation westward. In doing so he placed theories of
Chinese medicine within the purely Western debate regarding vitalism and mechanism as opposites.

Further, de Morant fiddled with the idea of Qi circulation. If as Unschuld says, he was the first to “list effects of acupuncture points according to organs affected,” he was transposing a new and foreign logic onto the system of Qi circulation. This western-anatomy based rigid logic could only serve to discredit acupuncture when it inevitably is perceived to be false. The incompleteness of the theory of Qi circulation in the “meridians” (also a de Morant translation) is being revealed right now as randomized control trials of acupuncture, based on point prescriptions, are showing no or little difference between “real” acupuncture based on the meridian system, and acupuncture not so based. In some studies randomly placed acupuncture needles are being shown to be about as effective as needles placed “non-randomly” on meridians. “Sham” acupuncture is being shown to be about as effective. It is not so much that acupuncture is being found ineffective. Rather, its effectiveness is being found to be separate from meridian theory. That may be because its actual effectiveness depends on observations using systemic correspondences not even considered in the study protocols. In fact, thus practiced, the “sham” and “real” acupuncture may appear about equal because they are equally disconnected from systemic correspondences used in Chinese medicine to make treatment decisions. My sense is that meridian theory may be another case of a rigid construct of Westerners being imposed on much more nuanced and complex theories of Qi present in Chinese medical literature.

To reply to the skeptics, they may continue to debunk vitalistic theory if they wish. To me it seems to have provided an engine of investigation into the nature of life and
matter and well worth tolerating for its tantalizing effect. It seems to be a force
influencing bioethical debates, better debated than not. These bioethical issues include
stem-cell research and embryonic research. It has been an acknowledgement of
unobservable phenomena and so puts humans, so arrogantly sure of their supremacy,
firmly in their place in the universe. This is a very Confucian idea!

What the skeptics cannot do is make a simplistic equation between traditional
Chinese medical theory and the theories of western vitalistic thinking. There may be
some common ground shared, some resonance of ideas between Qi and pneuma or anima.
The basic tension between life and non-life does not exist as an engine however, in
traditional Chinese medical or early scientific thinking. The very concept of vitalism
depends on this tension. Chinese medicine cannot be refuted based on a
misunderstanding of its most basic theoretical constructs.

3 Wheeler, p.8
5 Nuland, p. 40
6 Majno, G. The Healing Hand, Man and Wound in the Ancient World, Cambridge;
Harvard University Press, 1975, p. 330
7 Wheeler, p. 14
8 Wheeler, p. 32
9 Wheeler, p 22
10 Wheeler, p 222
11 Burwick F., Douglass P., eds. The Crisis in Modernism – Bergson and the vitalist
controversy. Cambridge, 1992
Skeptical Society, www.theness.com
13 Ekken, K. The Philosophy of Qi – The Record of Great Doubts, tr. from Japanese by
14 Ekken, p. 11
15 Ekken, p. 14
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