Biofeedback Medical Treatment Guidelines

Compiled and Edited by
The Biofeedback Society of California
Committee on Biofeedback Treatment Guidelines
for Work Injuries

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Biofeedback is a form of behavioral medicine, which assists patients in learning enhanced sensory discrimination to facilitate the acquisition of physiological self-regulation skills to reduce symptoms, identify and avoid aggravating activities, enhance function and speed recovery to pre-injury status. Biofeedback has been used in clinical settings for treatment and rehabilitation of injured workers for more than 30 years. As technology has advanced, treatment protocols have evolved. Much of Biofeedback research may be found in specialized journals, such as *Applied Psychophysiology and Biofeedback*. However, the wide diversity of applications may also be found in studies reported in professional journals of Physical, Occupational and Rehabilitation Medicine, Clinical Psychology, Physical and Occupational Therapy, Pain Management, all accessed through *Medline* listings.

Simply defined, Biofeedback is the process of identifying physiological variables such as muscle activity, peripheral skin temperature, regional blood flow, respiratory style and rate, heart rate variability, brainwaves and other measures of autonomic nervous system function for the purpose of helping the patient to develop a greater sensory awareness. This is achieved by the monitoring of these variables with the use of electronic instrumentation, which is then fed back to the individual visually or audibly, for the purpose of teaching the individual to gain some measure of physiological control. Once an initial assessment is made and individualized needs are identified, the Biofeedback Specialist acts as a coach to teach and guide each individual to reach targeted goals of increased function.

Treatment goals are set based upon the injury diagnosis, physiological assessment, physician orders and demands of the work tasks. The ultimate goal is returning physiological status to the pre-injury state by the greatest extent possible and transferring skills to the workplace to maximize functional tolerances while reducing the risk of re-injury. Education in conjunction with appropriate feedback facilitates transfer of self-regulation skills to ordinary and novel circumstances. Training includes independent practice by the injured person to strengthen new levels of awareness and self-control. It must be emphasized that this process of enhanced awareness and self-regulation is a powerful mechanism unique to Biofeedback. The more motivated a person is and the more they practice, the faster they may learn.

Heightened self-awareness also protects the patient from engaging in movements or behaviors that may aggravate or cause further injury. At the same time, work habits are modified or alternate work habits may be identified that reduce involvement or strain on injured tissues. In the functional application, feedback is used to retrain a work behavior to reduce involvement of injured structures. The process addresses work postures and positions, pacing and other work-related variables that may assist the patient in working safely to reduce the risk of re-injury.

Good candidates for Biofeedback include individuals with musculoskeletal injuries, where muscle dysfunction or stress responses effect or delay recovery; re-injured individuals or those who appear in need of altering work behaviors in some way; individuals for whom pain, sleep disturbances or poor self-regulation may perpetuate symptom aggravation and those with autonomic system dysregulation.

Recognized types of Biofeedback include the following:

a. Surface Electromyography (sEMG) – Used for self-management of pain and stress reactions involving muscle tension and for reduction of over-effort related to poor posture or undesirable movement habits.
b. Skin Temperature – Used for self-regulation of circulation through vasomotor control, reduction of arousal, management of pain and stress reactions, Reynaud's Phenomenon, and vascular headaches.
c. Respiratory Feedback (RFB) – Used for self-management of pain and stress reactions via control of breathing, alteration of hyperventilation responses/syndromes, and improvement in respiration in the presence of asthma or COPD.
d. Respiratory Sinus Arrhythmia (RSA) – Used for self-management for pain and stress reactions via synchronous control of heart rate and respiration. Respiratory sinus arrhythmia is a benign phenomenon, which consists of a small rise in heart rate during inhalation and a corresponding decrease during exhalation. This phenomenon has been observed in athletes and those engaged in meditation. It is thought to be a psychophysiological indicator of health.
e. Heart Rate Variability (HRV) – Used for self-management of stress responses via management of cardiac reactivity.
f. Electrodermal Response/Activity (EDR, EDA, GSR) –Used for self-management of stress responses involving regulation of (palmar) sweating and the resulting conductance of the skin.
g. Electroencephalograph (EEG or Quantified EEG, QEEG) – Used for self-management of various psychological/attentional states by regulation of brain waves.

The Biofeedback Certification Institute of America (BCIA) should certify biofeedback Specialists. Providers may have other licensure such as in physical therapy, nursing or social work. A licensed practitioner or physician may also supervise them. **"Biofeedback therapy always involves a therapist, a patient, and monitoring instrument capable of providing accurate physiological information."** (Yucha & Gilbert, 2004). Specific treatment guidelines and standard protocols are based on and supported by the following controlled research studies and references.

Studies

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Yucha, C., Gilbert, C. (2004). *Evidence-Based Practice in Biofeedback and Neurofeedback.* Association for Applied Psychophysiology and Biofeedback, Wheatridge, Colorado.

Upper Extremity Injuries

The following Upper Extremity Injuries have responded well with Biofeedback treatment. All or some of the listed strategies may be employed as part of the rehabilitation program.

1. Surface EMG biofeedback is recorded from involved muscles/muscle groups to develop discrimination skills between states of tension versus relaxation in painful regions. Peripheral skin temperature feedback from the hands or fingers to induce vasodilation is useful in reducing intensity of pain. Additional feedback modalities such as respiratory, RSA, EDA, or HRV feedback may also be employed as indicated through physiological evaluation during the intake session. Patients are instructed in relaxation and self-regulation strategies to reduce pain and load on the muscle-tendon units while lowering arousal.

2. Independent practice during this treatment phase emphasizes self-guided tension-perception and tension reduction drills during daily activities, as well as practice of self-control strategies for muscle relaxation and hand warming. Patients are also asked to utilize learned relaxation skills to reduce pain as needed during the day and at night to improve sleep quality.

3. Positional feedback is introduced during treatment to reduce potentially aggravating elbow, forearm, wrist and finger postures either at rest or during movement that may contribute to chronic muscle tension and continued strain on the tendon(s). EMG training is used to reduce muscle guarding due to pain as well as to develop rapid and full recovery of involved muscles after use. Minimization of musculoskeletal strain and development of muscle skill reduces the likelihood of re-injury. Patients are instructed to attend to selective relaxation of these muscles both at rest and during activities, using new levels of sensory awareness as a guide.

4. During the dynamic phase of treatment, work tasks are practiced with surface EMG feedback from appropriate muscle sites along with skin temperature of the hand to assess work habits and maintain physiological activity in target parameters. This goal may require changes of work technique, pacing (especially

work-rest cycles during repetitive tasks), work organization, or work set-up. Ergonomic principles and body mechanics may be reviewed during this phase.

Studies

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Thoracic Outlet Syndrome

Compression of the neurovascular bundle in the thoracic outlet that results in pain, dysesthesias and occasionally weakness in the arm. In most cases this is a vascular syndrome but in a small percentage of cases neurologic symptoms are prominent. Compression of neurovascular structures as they pass between the scalenus anterior and scalenus medius muscles can also cause this syndrome. Vasomotor symptoms usually affect the radial side of the hand, whereas neurologic symptoms usually involve the ulnar side of the hand (Tollison, et. al., 1994, Demeter, et. al., 1996).

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms and/or areas of entrapment. Postural feedback is emphasized for individuals with this symptom complex and strengthening of postural muscles may be appropriate.
2. Reinforce the release of scalene &/or pectoralis minor muscle tension that is being obtained from abdominal breathing, stretches, and relaxation exercises for intended to decrease sympathetic arousal associated with stress.
3. Improve the patient's ability to feel like they can affect their physical responses and symptoms through volitional EMG and temperature control.

4. Assist in avoiding re-injury through use of muscle and temperature control during practice of work tasks and selected movements.
5. If necessary, prepare for surgery.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 2 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Shoulder Injury

Conditions of the shoulder resulting in impairment can be divided into categories: Nonmechanical and mechanical. Nonmechanical problems are not related to specific activities or position. Mechanical conditions are symptomatic during certain activities and positions. They are reproducible and well localized. Acute injuries to the shoulder include contusions, ligamentous sprains, muscular strains and fractures (Demeter, et. al., 1996).

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms with goals including reduction of muscle guarding and improved strength and recruitment of stabilizers of the shoulder girdle
2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing and decrease sympathetic arousal through practice of relaxation and self-regulation procedures.
3. Improve the patient's ability to affect physical responses and symptoms while emphasizing recognition of sensory correlates of effective muscle control. Attention is given to increasing the recognition of successful self control.
4. Assist in avoiding re-injury through practice of appropriate muscle recruitment patterns during work task practice to facilitate transfer of skills and strengthen awareness of self-regulation skills.
5. If necessary, prepare for surgery with relaxation and muscle control skills.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Cervical Spine Injury

Cervical spine trauma itself may be divided into its neurologic, bony and ligamentous and muscular components, each giving rise to significant pain. The most frequent cervical spine traumatic event that causes pain is muscle sprain or strain, more commonly referred to as whiplash injury. Rapid, large changes in motion or force, as occur in cervical spine injury, may exceed the capacity of cervical musculature to compensate, leading to muscle strain and tears. Larger disruptive forces may cause bony and ligamentous damage in addition to the muscular injury. (Tollison, et. al., 1994)

Treatment and Training Guideline

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms.
2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing for the purpose of decreasing sympathetic arousal, associated with stress.
3. Improve the patient's awareness and ability to affect physical responses and symptoms.
4. Assist in avoiding re-injury through the individual returning to repetitive movement and bracing pattern(s). Training in stabilization of the upper quarter with appropriate musculature may be needed.
5. In necessary, prepare for surgery.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains

Studies

Middaugh, S. J. and W. G. Kee (1987). "Advances in electromyographic monitoring and biofeedback in the treatment of chronic cervical and low back pain." *Adv Clin Rehabil* 1: 137-72.

References

Kasman, G. S., J. R. Cram, et al. (1997). Cervical dysfunction. *Clinical applications in surface electromyography*. Gaithersburg, Maryland, Aspen Publishers, Inc: 415.

Cumulative Trauma Disorder (CTD)

CTD is a general term used for disorders with similar characteristics, affecting tissues of the body which include muscles, tendons and nerves. Defined as disorders that are caused, precipitated, or aggravated by repeated exertions or movements of the body. (Demeter, et. al., 1996) CTD can involve upper or lower extremities.

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms and/or areas of entrapment.
2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing for the purpose of decreasing sympathetic arousal, associated with stress.
3. Improve the patient's awareness and ability to affect responses and symptoms.
4. Assist in avoiding re-injury through the individual returning to repetitive movement and bracing pattern(s). Alternate work habits may be introduced to prevent aggravation of symptoms while increasing functional tolerances.
5. In necessary, prepare for surgery.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:

1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains

Studies

Spence, S.H., Sharpe, L., Newton-John, T., Chamion, D., (1995). "Effect of EMG Biofeedback Compared to Applied Relaxation Training with Chronic Upper Extremity Cumulative Trauma Disorders." Elsevier Science B.V., *Pain*, 63, 199-206.

Spence, S. H., L. Sharpe, et al. (2001). "An investigation of symptom-specific muscle hyperreactivity in upper extremity cumulative trauma disorder." *Clin J Pain* 17(2): 119-28.

Repetitive Strain Injury (RSI)

These disorders typically affect soft tissues (muscles, tendons and nerves), and result from highly repetitive motions or tasks. They are generally associated with cumulative trauma disorders caused, precipitated, or aggravated by repeated exertions or movement of the body. Common examples include tendonitis, some cases of neuritis, and de Quervain's Tenosynovitis**.** (Demeter et. al., 1996).

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms and/or areas of entrapment.
2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing for the purpose of decreasing pain while lowering sympathetic arousal through general relaxation.
3. Improve the patient's awareness of their ability to affect their physical responses and symptoms and use new awareness to cue behavior change including selective relaxation, pacing, or use of alternative movements.
4. Assist in avoiding re-injury through the individual returning to repetitive movement and bracing pattern(s), as well as by identifying and training alternate work habits that reduce strain on injured tissues.
5. If necessary, prepare for surgery with relaxation and improved self-regulation skills.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:

4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains

Studies

Moore, L.E, & Wiesner, S.L. (1996). "Hypnotically-induced vasodilation in the treatment of repetitive strain injuries." *American Journal of Clinical Hypnosis*, 39(2), 97-104.

Jensen, M. P., Grierson, C., Tracy-Smith, V., Bacigalupi, S. C., Othmer, S. (in press). "Neurofeedback treatment for pain associated with complex regional pain syndrome Type I". *Journal of Neurotherapy*.

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Carpal Tunnel Syndrome

Compression of the median nerve within the carpal tunnel of the wrist is termed carpal tunnel syndrome. Although, the syndrome is associated with a variety of medical conditions, it has a high incidence with repetitive activities of the wrists and digits. Wrist positions such as the extremes of flexion and extension as well as ulnar deviation increase the pressure with the within the carpal canal (Demeter, et, al., 1996).

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms and/or areas of entrapment. Peripheral skin temperature feedback is essential to increase distal circulation to minimize numbness, pain, and tingling.

2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing for the purpose of decreasing pain and sympathetic arousal associated with stress.
3. Improve the patient's ability to affect their physical responses and symptoms through improved wrist position, hand warming to increase circulation to tissues of the wrist and hand, and selective muscle relaxation to minimize strain of wrist tendons.
4. Assist in avoiding re-injury by training the individual to recognize and maintain neutral posture of the wrist during task performance rather than returning to aggravating movements or work habits.
5. If necessary, prepare for surgery with special emphasis on development of hand warming skills to ensure good circulation during healing.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains

References

Donaldson, C.C.S., Nelson, D.V., Skubick, D.L.& Clasby, R.G., (1998). "Potential Contributions of Neck Muscle Dysfunctions to Initiation and Maintenance of Carpal Tunnel Syndrome." *Applied Psychophysiology and Biofeedback*, vol 23, No. 1, 59-72.

Skubick, D. L., Clasby, R., Donaldson, C. C. S., & Marshall, W. M. (1993). "Carpal tunnel syndrome as an expression of muscular dysfunction in the neck." *Journal of Occupational Rehabilitation*, 3, 31-44.

Hand Dystonia

Dystonia is a term that refers to an abnormally increased muscle tone. Dystonia is a syndrome of sustained muscle contractions, frequently causing twisting and repetitive movements and resulting in a fixed abnormal posture. Focal dystonia (writer's cramp, spasmodic torticollis) refers to single limb involvement while segmental dystonia affects two or more adjacent parts of the body. (DeLisa, et. al., 1993)

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements from the involved quarter may be employed that relate to the symptoms. Muscle discrimination practice (alternative recruitment of agonist, quieting of antagonist and then the reverse) is important to improve sensory awareness and muscle control.
2. Reinforce the release of muscle tension that is being obtained from slow stretches, muscle control exercises, and abdominal breathing for general relaxation and lowering of arousal.
3. Improve the patient's ability to feel like they can affect their physical responses and symptoms through the feedback process. Postural issues and hand warming can be addressed as indicated to alter movement patterns and further improve self-regulation.
4. Assist in reducing dystonic motions by modifying any aspects of posture and movement technique that can be altered.
6. Treatment time will usually overlap return-to-work.

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 time a week

Time to skill acquisition:
12 to 16 sessions

Maximum Duration:
16 to 20 sessions. Treatment beyond 16 sessions must be documented with respect to continued improvement and the expectation of ability to facilitate positive functional gains.

Studies

Deepak, K.K. & Behari, M. (1999). "Specific muscle EMG biofeedback for hand dystonia." *Applied Psychophysiology and Biofeedback*, 24(4), 267-80

References

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Brown, D. M. and Nahai, F. (1983). "Biofeedback strategies of the occupational therapist in total hand rehabilitation." In Basmajian, J. V., ed. *Biofeedback: principles and practice for clinicians*. Baltimore: Williams & Wilkins.

O'Neill, M. A., K. A. Gwinn, et al. (1997). "Biofeedback for writer's cramp." *Am Occup Ther* 51(7): 605-7.

Back and Lower Extremity Injury

The following Lower Extremity Injuries have responded well with Biofeedback treatment. All or some of the listed strategies may be employed as part of the rehabilitation program.

1. Surface EMG biofeedback is recorded from involved muscles/muscle groups to develop discrimination skills between states of tension versus relaxation in painful regions. Peripheral skin temperature feedback from the feet and toes to induce vasodilation is useful in reducing intensity of pain. Patients are instructed in relaxation and self-regulation strategies to reduce pain and load on the muscle-tendon units.

2. Independent practice during this treatment phase emphasizes self-guided tension-perception and tension reduction drills during daily activities, as well as practice of self-control strategies for muscle relaxation and warming of extremities. Patients are also asked to utilize developing relaxation skills to reduce pain as needed during the day and at night to improve sleep quality.

3. Positional feedback is introduced during treatment to reduce potentially aggravating postures either at rest or during movement that may contribute to chronic muscle tension and continued strain on the tendon(s). EMG training is used to reduce muscle guarding due to pain as will as to develop rapid and full recovery of involved muscles after use. Minimization of Musculoskeletal strain and development of muscle skill reduces the likelihood of re-injury. Patients are instructed to attend to selective relaxation of these muscles both at rest and during activities, using new levels of sensory awareness as a guide.

4. During the dynamic phase of treatment, work tasks are practiced with surface EMG feedback from appropriate muscle sites. This goal may require changes of work technique, pacing (especially work-rest cycles during repetitive tasks), work organization, or work set-up. Ergonomic principles and body mechanics may be reviewed during this phase.

The Biofeedback Specialist may specialize in one approach or many. This can depend largely on the training of the therapist. It is recommended that the referring source be familiar with the therapist's background and approach.

Studies

Croce, R. V. (1986). "The effects of EMG biofeedback on strength acquisition." *Biofeedback and Self Regulation,* 11(4), 299-310.

Draper V., Ballard L., (1991). "Electrical stimulation versus electromyographic biofeedback in the recovery of quadriceps femoris muscle function following anterior cruciate ligament surgery." *Phys. Ther*.; 71:455-64.
Fiero, P. L., D. I. Galper, et al. (2003). "Thermal biofeedback and lower extremity blood flow in adults with diabetes: is neuropathy a limiting factor?" *Appl Psychophysiol Biofeedback* 28(3): 193-203.
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LeVeau B and Rogers C. (1980). "Selective training of the vastus medialis muscle using EMG biofeedback." *Physical Therapy*. 60(11):1410-5.

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Harrison VF, Mortensen OA. (1962). "Identification and voluntary control of single motor unit activity in the tibialis anterior muscle." *Anat Rec*;144:109-16.
Koheil R, Mandel AR. (1980). "Joint position biofeedback facilitation of physical therapy in gait training." *Am J Phys Med*; 59:288-97.

Spinal Cord Injury

SCI is a traumatic insult to the spinal cord that can result in alterations of normal motor, sensory and autonomic function. Paraplegia involves the lower extremities. Quadriplegia involves all extremities. Injuries to the cervical, thoracic and thoracolumbar junction, spinal fractures and dislocations, all cause SCI's. Spinal cord injury is commonly associated with head injuries. (DeLisa, et. at. 1993).

Treatment/Training Guidelines:

Biofeedback methodology dealing with Spinal Cord Injury (SCI) can be broadly broken down into three approaches.

1. The first deals with the functional level of the patient. There are ranges of techniques used to help the patient regain the use of muscles that have been affected by the injury. These techniques are based on the patient relearning how to recruit motor units at or below the level of lesion.
2. Treating both nocioceptive and neuropathic pain in an individual with SCI is common. Biofeedback may be applied in the same way as treatment of chronic pain
3. There are a range of emotional responses to SCI and the pain it may produce. Biofeedback is an efficacious way of helping the patient deal with these emotions. Please see the specific diagnoses for further information.

Time to produce initial effect:

4 to 6 sessions

Frequency:

1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Studies

Brucker, B. S., & Bulaeva, N. V. (1996). "Biofeedback effect on electromyography responses in patients with spinal cord injuries." *Archives of Physical Medicine and Rehabilitation, 77*(2), 133-137.

Brucker, B. S., & L.P., I. (1977). "Biofeedback as an experimental treatment for postural hypotension in a patient with a spinal cord lesion." *Archives of Physical Medicine and Rehabilitation, 58*(2), 49-53.

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Goldsmith, M. F. (1985). "Computerized biofeedback training aids in spinal injury rehabilitation." *Jama* 253(8): 1097-9.

Nacht, M.B., Wolf, S.L., Coogler, C.E. "Use of electromyographic biofeedback during the acute phase of spinal cord injury." *Phys Ther* 1982;62:290.

Stein, R. B., Brucker, B. S., & Ayyar, D. R. (1990). "Motor units in incomplete spinal cord injury: Electrical activity, contractile properties and the effects of biofeedback." *Journal of Neurology, Neurosurgery and Psychiatry,* 53(10), 880-885.

Knee and Ankle Injury

Injuries to the knee may involve a number of different conditions including fractures (intercondylar, osteochondral, tibial plateau, patellar); Ligament injuries (anterior and posterior curciate) and miniscal tears and injuries resulting from trauma to the quadriceps, fracture of the patella, rupture of the quadriceps (patellar) tendon, lacerations or crush njuries. (Demeter, 1996) Similarly, injuries of the ankle result from fractures, dislocations, cuts, lacerations, punctures, strains and strains caused by blows to the foot-ankle area. (Demeter, et. al. 1996)

Treatment and Training Guidelines

1. Improve the patient's awareness to assist in the control of muscle activity. A variety of muscle (EMG) placements may be employed that relate to the symptoms.
2. Reinforce the release of muscle tension that is being obtained from stretches, exercises and abdominal breathing for the purpose of decreasing sympathetic arousal, associated with stress.

3. Improve the patient's ability to feel like they can affect their physical responses and symptoms.
4. Assist in avoiding reinjury through the individual returning to repetitive movement and bracing pattern(s).
5. In necessary, prepare for surgery.
6. Treatment time may or may not overlap return-to-work or maximum medical improvement (MMI).

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Studies

Fernie G, Holden J, Soto M., (1978). "Biofeedback training of knee control in the above-knee amputee." *Am J Phys Med*; 57:161.

Ingersoll, C.D. and Knight K.L. "Patellar location changes following EMG biofeedback or progressive resistive exercises." (1991). *Med Sci Sports Exerc*. 23:1122-7

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Chronic Pain Disorder

Chronic pain is pain that lasts beyond the period of time required for tissue damage to heal. It is a complex condition and there are many factors that can interact with this condition. Pain typically is considered to be chronic if it lasts more than six months. Biofeedback methodology and protocols dealing with Chronic Pain can be broadly divided into three approaches. Biofeedback protocols commonly used to help with the following conditions are primarily chosen by what the therapist, patient and/or the referral source see as the goal of the therapy.

1. The first deals with the underlying musculoskeletal symptoms that occur after the initial injury. The Biofeedback Specialist will use appropriate modalities to help patients recognize and reduce muscular bracing and guarding behaviors that contribute to the experience of high levels of pain. Increases in peripheral skin temperature of the involved limb(s) may also be included in relaxation training in cases where increases in circulation and blood flow are essential to decreasing pain.
2. The second protocol deals with training the individual to increase awareness of the body, to detect early signs of symptom exacerbations, to implement self-regulation strategies when needed, and to change behaviors associated with chronic pain. The biological, psychological and social context of their problems and how they apply to pain levels are addressed.
3. The third deals with addressing conditions such as anxiety and depression that are secondary but result from the original injury.

Studies

Albright, G. L. and A. A. Fischer (1990). "Effects of warming imagery aimed at trigger-point sites on tissue compliance, skin temperature, and pain sensitivity in biofeedback-trained patients with chronic pain: a preliminary study." *Percept Mot Skills* 71(3 Pt 2): 1163-70

Flor, H. and Birbaumer, N. (1993). “Comparison of the efficacy of EMG biofeedback, cognitive-behavioral therapy, and conservative medical interventions in the Psychology treatment of chronic musculoskeletal pain.” *J of Consulting and Clinical* 61: 653-658.

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Flor, H., N. Birbaumer, et al. (1991). "Stress-related electromyographic responses in patients with chronic temporomandibular pain." Pain 46(2): 145-52.

Flor, H., T. Fydrich, et al. (1992). "Efficacy of multidisciplinary pain treatment centers: a meta-analytic review." *Pain* 49(2): 221-30.

Flor, H., B. Knost, et al. (2002). "The role of operant conditioning in chronic pain: an experimental investigation." *Pain* 95(1-2): 111-8.

Nielson, W.R. & Weir, R. (2001). “Biopsychosocial approaches to the treatment of chronic pain.” *Clinical Journal of Pain,* 17(4 Suppl), S114-S127.

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Flor, H., G. Haag, et al. (1983). "Efficacy of EMG biofeedback, pseudotherapy, and conventional medical treatment for chronic rheumatic back pain." Pain 17(1): 21-31.

Low Back Pain

The occurrence of pain generally located in the lower back region may have multiple origins and include involvement from multiple sources. Pain types and causes may have neurological (with or without radiculopathy), orthopedic (involving injury to bones, ligaments and tendons), mechanical (related to specific movements, postures or activities), or psychogenic origins.

Treatment/Training Guidelines:

1. Initial goal is reduction of pain. Pain suppression may be achieved by a choice of the most effective method available, i.e. diaphragmatic breathing, general relaxation, EMG reduction of spasm, etc. This will vary among patients.
2. Surface EMG biofeedback is recorded from involved muscles/muscle groups to develop discrimination skills between states of tension versus relaxation in painful regions. Symmetry of EMG activity is re-established when absent.
3. Increased range of motion in the low back is facilitated via muscle control if indicated. EMG monitoring/feedback and the development of relaxation skills can assist specific/ general muscle groups to relax and increase movement. Strengthening of core stabilizers can assist in this process.
4. Teach self-regulation for prevention of future injury. Increased functional awareness helps patients in preventing symptoms from occurring by becoming aware of early warning signs that precede symptoms flare-ups. Self-regulation training may address postural alignment, pain reduction techniques, stress coping strategies, and provide homework that strengthens learned skills. These then empower the patient to increase function through reliance on new skills and abilities.

Time to produce initial effect:

4 to 6 sessions

Frequency:

1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Studies

Asfour, S. S., T. M. Khalil, et al. (1990). "Biofeedback in back muscle strengthening." *Spine* 15(6): 510-3.

Flor, H., G. Haag, et al. (1986). "Long-term efficacy of EMG biofeedback for chronic rheumatic back pain." *Pain* 27(2): 195-202.

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Traue, H. M., Kessler, M., & Cram, J. (1992). "Surface EMG topography and pain distribution of pre-chronic back pain patients". *International Journal of Psychosomatics, 39,* 18-27.

Vlaeyen, J. W., Haazen, I.W., Schuerman, J. A., Kole-Snijders, A.M & van Eek, H. (1995). "Behavioral rehabilitation of chronic low back pain: Comparison of an operant treatment , an operant-cognitive treatment and an operant-respondent treatment." *Clinical Psychology*, 34(Pt 1), 95-118.

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Keefe, F. J. and L. A. Bradley (1984). "Behavioral and psychological approaches to the assessment and treatment of chronic pain." *Gen Hosp Psychiatry* 6(1): 49-54.
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Middaugh, S., & Kee, W.G. (1987). "Advances in electromyographic monitoring and biofeedback in the treatment of chronic cervical and low back pain." In M.G. Eisenburgh & R.C. Grzesiak (Eds.), *Advances in Clinical Rehabilitation* (Vol. 1, pp. 137-172). New York: Spinger.
Wolf, S. L., & Basmajian, J. V., "Assessment of paraspinal electromyographic activity in normal subjects and in chronic pain patients using a muscle biofeedback device." In E. Asmussen & K. Jorgensen (Eds.), International series on biomechanics VIB (pp. 319-324. Baltimore: University Park Press.
Wolf, S. L., Nacht, M., & Kelly, J. L. (1982). "EMG feedback training during dynamic movement for low back pain patients." *Behavior Therapy*, 13, 395-406
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Myofascial Pain Syndrome

In simplest terms, myo means muscle and fascia refers to tissues. Myofascial Pain is pain that arises from muscles (often containing one or more trigger points) and the surrounding connective tissue and facial sheath. Myofascial Pain Syndromes may involve referred pain from trigger points occurring or activated in response to strain by acute or chronic overload in any skeletal muscle. Perpetuating factors act to convert an acute single-muscle syndrome into a chronic pain syndrome. These factors may be systemic and mechanical. Systemic factors increase the irritability of the skeletal muscles throughout the body. Mechanical factors overload and aggravate trigger points in specific muscles, depending on which muscle or muscles are overstressed. One of the most common systemic Myofascial Pain Syndromes causing musculoskeletal pain is fibromyalgia (Tollison, et. al., 1996)

Treatment/Training Guidelines

1. Initial goal is reduction of pain. Pain suppression may be achieved by a choice of the most effective method available, i.e. diaphragmatic breathing, general relaxation, EMG reduction of muscle tension, etc. This will vary among patients.
2. Temperature training. Increases in overall peripheral hand temperature along with EMG feedback help affect lower arousal levels.
3. Teach self-regulation for prevention of excessive stress responses and improvement in posture. Increased functional awareness helps patients in preventing symptoms from occurring and becoming aware of early warning signs the produce symptoms. This may include increased stress reduction techniques, postural feedback to improve alignment and reduce muscle effort, and homework that strengthens learned skills.

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with
respect to need, expectation an ability to facilitate positive symptomatic or functional gains

References

Donaldson, C. C., D. V. Nelson, et al. (1998). "Disinhibition in the gamma motoneuron circuitry: a neglected mechanism for understanding myofascial pain syndromes?" *Appl Psychophysiol Biofeedback* 23(1): 43-57.

Keefe, F. J. and E. Dolan (1986). "Pain behavior and pain coping strategies in low back pain and myofascial pain dysfunction syndrome patients." *Pain* 24(1): 49-56.

Complex Regional Pain Syndrome I & II/ Reflex Sympathetic Dystrophy

CRPS or RSD is a neurogenic disorder characterized by pain out of proportion to the level expected, swelling, vasomotor changes (autonomic dysfunction) and stiffness of the upper extremity. It can occur following a single traumatic event or a surgical procedure to the upper extremity. Alternatively, it can begin insidiously after the most trivial of injuries. Autonomic hyperactivity has been implicated in the syndrome and nerve injuries are often linked to CRPS.
(Demeter, et. al., 1996)

Treatment/Training Guidelines

1. Initial goal is reduction of pain. EMG reduction of muscle tension in affected limbs is of primary concern to reduce bracing and guarding.
2. Temperature training. Increases in overall peripheral hand temperature along with EMG feedback help affect lower arousal levels and increase needed circulation.
3. Pain suppression may be achieved by a choice of the most effective method available, i.e. diaphragmatic breathing, general relaxation, etc. This will vary among patients.
4. Teach self-regulation for prevention of inappropriate stress responses. Increased functional awareness helps patients in preventing symptoms from occurring and becoming aware of early warning signs that produce symptoms. This may

include increased stress reduction techniques and homework that strengthens learned skills.

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation an ability to facilitate positive symptomatic or functional gains.

Studies

Grunert, B. K., C. A. Devine, et al. (1990). "Thermal self-regulation for pain control in reflex sympathetic dystrophy syndrome." *J Hand Surg* [Am] 15(4): 615-8.

Jensen, M.P., Grierson, C., Tracy-Smith, V., Bacigalupi, S.C., Othmer,S. (in press).“Neurofeedback treatment for pain associated with Complex Regional Pain Syndrome Type I”, *Journal of Neurotherapy*

Phantom Limb Pain

Phantom limb pain is pain in an amputated portion of the body. It appears to be related to de-afferentation of neurons and their spontaneous and evoked hyper-excitability. Pain may be continuous and is often reported as cramping, aching or burning with occasional, superimposed electric-like components. The increased sensitivity of sprouts from cut peripheral nerves to noradrenaline and adrenaline may partially explain why adrenergic-influenced emotional states (e.g., stress, anxiety) occasionally provoke attacks of phantom limb pain. (DeLisa, et. al., 1993)

Treatment/Training Guidelines

1. Initial goal is reduction of pain. Temperature training to increase needed circulation. Increases in overall peripheral limb or stump temperature along with EMG feedback help affect lower arousal levels.
2. Pain suppression may be achieved by a choice of the most effective method available, i.e. diaphragmatic breathing, general relaxation, etc. This will vary among patients.
3. Teach self-regulation for prevention of inappropriate stress responses. Increased functional awareness helps patients in preventing symptoms from occurring and becoming aware of early warning signs that produce symptoms. This may

include increased stress reduction techniques and homework that strengthens learned skills.

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation and ability to facilitate positive symptomatic or functional gains.

Studies

Sherman, R. A. and G. M. Bruno (1987). "Concurrent variation of burning phantom limb and stump pain with near surface blood flow in the stump." *Orthopedics* 10(10): 1395-402.

Sherman, R. A., N. Gall, et al. (1979). "Treatment of phantom limb pain with muscular relaxation training to disrupt the pain--anxiety--tension cycle." *Pain* 6(1): 47-55.

Sherman, R. A., V. D. Griffin, et al. (1992). "Temporal relationships between changes in phantom limb pain intensity and changes in surface electromyogram of the residual limb." *Int J Psychophysiol* 13(1): 71-7.

Sherman, R. A., C. J. Sherman, et al. (1984). "Chronic phantom and stump pain among American veterans: results of a survey." *Pain* 18(1): 83-95.

References

Belleggia, G. and N. Birbaumer (2001). "Treatment of phantom limb pain with combined EMG and thermal biofeedback: a case report." *Appl Psychophysiol Biofeedback* 26(2): 141-6.

McCabe, C. S., R. C. Haigh, et al. (2004). "Phantoms in rheumatology." *Novartis Found Symp* 260: 154-74; discussion 174-8, 277-9.

Sherman, R. A., J. G. Arena, et al. (1989). "The mystery of phantom pain: growing evidence for psychophysiological mechanisms." *Biofeedback Self Regul* 14(4): 267-80

Sherman, R. A. (1994). "Phantom limb pain. Mechanism-based management." *Clin Podiatr Med Surg* 11(1): 85-106.

Headache – Adult

Headache pain may be the most common medical complaint known. Headache may be intense whether its source is benign or malignant. Although the vast majority of

headaches are unrelated to structural neurologic disease, headache can also be the presenting complaint in potentially life-threatening disorders such as meningitis, cerebral hemorrhage and brain tumor. Although headache classifications are debated, headache types are divided into vascular, tension, traction and inflammatory. The category of vascular headache includes migraine, with or without aura, as well as cluster headache, toxic vascular headache, hypertensive headache, and more complicated forms of migraine, such as hemiplegic, opthalmoplegic and basilar artery migraine. The common pathway in these headaches is a tendency to vascular dilatation that provokes the headache phase.
(Tollison, et. al., 1994)

Treatment/Training Guidelines

1. Initial goal is reduction of pain. Pain suppression may be achieved by a choice of the most effective method available, i.e. diaphragmatic breathing, general relaxation, EMG reduction of muscle tension, etc. This will vary among patients.
2. Temperature training. Increases in overall peripheral hand temperature along with EMG feedback help affect lower arousal levels.
3. Teach self-regulation for prevention of inappropriate stress responses. Increased functional awareness helps patients in preventing symptoms from occurring and becoming aware of early warning signs the produce symptoms. This may include increased stress reduction techniques and homework that strengthens learned skills.

Time to produce initial effect:
4 to 6 sessions

Frequency:
1 to 3 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:
12 to 16 sessions. Treatment beyond 16 sessions must be documented with respect to need, expectation and ability to facilitate positive symptomatic or functional gains.

Studies

Arena, J. G., Bruno, G.M., Hannah, S.L., Meader, K.J. (1995). "Comparison of frontal electromyographic biofeedback training, trapezius electromyographic biofeedback training and progressive muscle relaxation therapy in the treatment of tension headache." *Headache*, 35 (7), 411-419.

Carmen, J. PhD. (2004) Passive Infrared Hemoencephalography: Four Years and 100 Migraines. *Journal of Neurotherapy*. Vol 8(3) p. 23-51.

Bogaards, M. C. and M. M. ter Kuile (1994). "Treatment of recurrent tension headache: a meta-analytic review." *Clin J Pain* 10(3): 174-90.
McCrory, D.C., Penszien, D.B., & Rains, J.C. (1996) “Efficacy of behavioral treatments for migraine and tension-type headache: Meta-analysis of controlled trials [Abstract].” *Headache*, 36,272.
Rokicki L. A., Holroyd, K. A., France C.R. Lipchik, G.L., France, J. L., Kvaal, S.A. (1997). “Change mechanisms associated with combined relaxation/EMG biofeedback training for chronic tension headache.” *Applied Psychophysiology & Biofeedback*, 22(1), 21-41.
Sarafino, E. P. and P. Goehring (2000). "Age comparisons in acquiring biofeedback control and success in reducing headache pain." *Ann Behav Med* 22(1): 10-6.
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Kasman, G. S., J. R. Cram, et al. (1997). Tension-type headache. *Clinical applications in surface electromyography*. Gaithersburg, Maryland, Aspen Publishers, Inc: 241-246.
McGrady, A., Wauquier, A., Mcneil, A., & Gerard, C. (1994). “Effect of biofeedback-assisted relaxation on migraine headache and changes in cerebral blood flow velocity in the middle cerebral artery.” *Headache*, 34(7), 424-428.
Martelli, M. F., R. L. Grayson, et al. (1999). "Posttraumatic headache: neuropsychological and psychological effects and treatment implications." *J Head Trauma Rehabil* 14(1): 49-69.

Traumatic Brain Injury

Quantified or Computerized Electroencephalography (QEEG) is a modification of standard EEG using computerized analysis of statistical relationships between power, frequency, timing and distribution of scalp recorded brain electrical activity. These statistically generated values are then compared to those recorded from selected control and patient populations, generally using multiple regression analysis of multiple

measurements and calculated parameters. A statistically derived probability statement regarding the likelihood of a patient belonging to a pathological population in comparison to the control non-pathological population is then generated.

Treatment/Training Guidelines:

1. Indications for Use: QEEG is rarely indicated in the initial diagnostic assessment of MTBI. It may occasionally be used when seizures, dementia or cerebrovascular disease are diagnostic considerations. In moderate and severe TBI the results of QEEG are almost always redundant with traditional EEG, neurologic, radiologic and psychometric evaluations. As a diagnostic tool for MTBI, QEEG is considered investigational.

2. Practice Requirements of QEEG: QEEG is based upon sophisticated technical and statistical methodologies. Therefore, adherence to some type of technical standards such as outlined by the American EEG Association is necessary. The QEEG practitioner should possess EEG board certification from a national certifying organization, documented additional training relevant to QEEG and "hands on" additional training with one or more qualified QEEG practitioners.

3. Treatment of patients with EEG Biofeedback has shown good results in patients when they are specifically trained to recognize and regulate brainwave patterns. Training protocols are similar to other biofeedback applications in which the patient is instructed to increase self-regulation. The EEG feedback continuously informs the patient of brain frequency activity or inactivity. Independent practice by the injured person serves to strengthen attention, awareness and self-control. Patients are also asked to utilize learned relaxation skills to reduce pain as needed during the day and at night to improve sleep quality.

4. Current applications for TBI patient include cognitive retraining and increasing attentional abilities. EEG Biofeedback has also shown good results with decreases in autonomic arousal, anxiety, depression and pain.

Time to produce initial effect:
4 to 6 sessions

Frequency:
2 to 4 times a week

Time to skill acquisition:
10 to 12 sessions

Maximum Duration:

30 to 40 sessions. Treatment beyond 40 sessions must be documented with respect to need, expectation and ability to facilitate positive symptomatic or functional gains.

Studies

Brudny, J., Korein, J., Grynbaum, B. B. and Sachs-Frankel, G. (1977). Sensory feedback therapy in patients with brain insult. Scand. J. Rehabil. Med., 9: 155-163.

Keller, I (2001) "Neurofeedback therapy of attention deficits in patients with traumatic brain injury." *Journal of Neurotherapy*, 5 (1/2), 19-32.

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LaVaque, T. J., Hammond, D. C., Trudeau, D., Monastra, V., Perry, J., Lehrer, P., Matheson, D., & Sherman, R. (2002). "Template for developing guidelines for the evaluation of the clinical efficacy of Psychophysiological evaluations. *Applied Psychophysiology and Biofeedback*, 27 (4), 273-281. Co-published in *Journal of Neurotherapy,* 6 (4), 11-23.

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