

3 *Biofeedback in Medicine*

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Abstract: Biofeedback is a treatment technique in which people are trained to improve their health by using signals from their own bodies. Ever since its advent, biofeedback has made rapid strides in the field of medicine. Biofeedback modalities like temperature, EMG, EDR (electrodermal response) and EEG biofeedback have been extensively tried in the management of diseases, particularly the stress-induced ones. *Biofeedback is an important tool for stress management and is effective in various diseases like anxiety, hypertension, migraine, tension headache, epilepsy, chronic pain, chronic constipation, fecal incontinence, irritable bowel syndrome and bronchial asthma. Besides the conventional forms of biofeedback, the development of other modalities like Hemoencephalography (HEG) and Heart rate variation (HRV) biofeedback has extended the scope of biofeedback in medicine. Biofeedback can reduce or even eliminate the need for medication and can be useful for prophylaxis of certain diseases. Emergence of telemedicine has added new possibilities for learning biofeedback by the patient even if the service provider is at a remote place. All clinicians should be conversant with this therapeutic modality as it may be useful in conditions refractory to conventional treatment. However, inspite of extensive clinical trials, more research is required for recommendation of biofeedback in diseases where its role is not yet specifically known.*

What is Biofeedback?

Biofeedback is a form of self-regulation in which individuals learn to control physiological responses by providing them with an information signal, as sensory feedback, about biological conditions of which they may not be ordinarily aware. Feedback responses include muscle tension, skin surface temperature, brain wave activity, electrodermal response, blood pressure and heart rate. In combination with therapeutic instruction and practice, the feedback signals enable patients to become active participants in the rehabilitation or health maintenance process.¹ Biofeedback involves the application of operant conditioning to gain control of visceral, somatomotor, or central nervous system activities.²

Biofeedback emerged as a treatment method from pioneering learning research during the 1950s of experimental psychologists, such as Neal Miller. It became a clinical modality in the late 1960s.¹

Biofeedback Modalities

Different techniques may be used by the therapist to gather information about the body's responses. Selection of the right technique for an individual will depend on his particular health problems and objectives. Machines and techniques include:

Electromyogram (EMG) Biofeedback

An EMG uses electrodes or other types of sensors to measure muscle tension. By the EMG alerting one to muscle tension, one can learn to recognize the feeling of increased muscle tension early and try to control the tension right away. EMG is mainly used to promote the relaxation of the muscles involved in backaches, headaches, neck pain and grinding the teeth (bruxism). An EMG may be used to treat some illnesses in which the symptoms tend to worsen under stress, such as asthma and ulcers.

Temperature Biofeedback

Skin temperature can be measured by sensors attached to fingers or feet. The temperature often drops when one is under stress, so a low reading can prompt one to begin relaxation techniques. Temperature biofeedback can help treat certain circulatory disorders, such as Raynaud's disease,³ or reduce the frequency of migraines.⁴

Electrodermal Response (EDR) Biofeedback

The activity of the sweat glands and the amount of perspiration on the skin can be measured by sensors, alerting one to anxiety. This information can be useful in treating emotional disorders like phobias, anxiety and stuttering.

Electroencephalogram (EEG) Biofeedback

The evolution of microcomputers, miniaturization, and digital technology has caused a rejuvenation in EEG feedback, re-christened "neurofeedback" or "neurofeedback therapy" (NFT). Among the areas of growing importance to clinicians include quantified (Q) EEG, the training of peak or optimal performance. ADD (Attention deficit disorder)/ADHD (Attention deficit hyperactivity disorder), treatment of dissociation, pain management in fibromyalgia and other areas of chronic pain, and enhancing mental functioning in the elderly. Modern EEG feedback equipment offers real time topographic EEG mapping in addition to additional channels that measure EMG, ECG (electrocardiogram) and EDR.¹

Other Types of Biofeedback Instruments

Other biofeedback machines can monitor heart rate, blood pressure and respiration all of which change in response to stress. Hemoencephalography biofeedback device monitors blood perfusion or blood oxygenation inside the brain with an infrared sensor on a headband. Practice of activating certain sites on the head, enhances a corresponding function in the brain.

Comprehensive biofeedback training involves working with a therapist using any combination of several different biofeedback modalities (skin conductance, temperature, muscle tension, heart rate variability, respiration, and brain wave patterns). Typically, about six sessions of this type of training are required to learn self-regulation.

How Does Biofeedback Work?

As a Stress Modifier

Biofeedback operates on the notion that we have the innate ability and potential to influence the autonomic functions of our bodies through the exertion of will and mind. Biofeedback shows the physiological effects of stress and our 'behavior' directly as they occur and in the hands of a trained clinician or therapist, can help the patient to go through a learning process. In this process the patient becomes aware of the effects of stress on the body and learns how to make the required 'behavioral' or 'lifestyle' changes.

Biofeedback is often aimed at changing habitual reactions to stress that can cause pain or disease. *Most patients who benefit from biofeedback are trained to relax and modify their behavior. Relaxation is a key component in biofeedback treatment of many disorders, particularly those brought on or*

*made worse by stress. In itself, relaxation is characterized by a decreased metabolism, heart rate, blood pressure, and rate of breathing as well as an increase in skin temperature. Feedback of physical responses such as skin temperature and muscle tension provides information to help patients recognize a relaxed state. The feedback signal may also act as a kind of reward for reducing tension. Constitutive nitric oxide as a result of the relaxation approach may crucially contribute to potentially beneficial outcomes and effects in diverse pathologies, exerting a global healing effect.*⁵

For Skill Learning

The value of feedback signal as information and reward may be even greater in the treatment of patients with paralyzed or spastic muscles. With these patients, biofeedback seems to be primarily a form of skill training. Stroke victims with paralyzed arms and legs, for example, know through the signals on the biofeedback machine that some parts of their affected limbs remain active. This signal can guide the exercises that help patients regain use of their limbs.

Neurophysiological studies have shown that the phasic oscillation during epilepsy reflects an inhibitory state of the sensorimotor system. Operant learning of sensory motor rhythm production results in an upregulation of excitation thresholds within the thalamocortical sensory and motor circuitry, which in turn is associated with reduced susceptibility to seizures.⁶

Clinical Studies on Biofeedback

Biofeedback has been found to be useful in various diseases as shown in Table 3.1. Results of clinical trials of biofeedback in some of the common diseases would be briefly discussed here.

Anxiety

Very few well-controlled, randomized studies have shown biofeedback to be superior to other relaxation and self-control methods for reducing anxiety. Most show biofeedback (EMG, EDR, thermal, or neurofeedback) to be roughly equivalent to progressive relaxation.^{7,8}

Headache

Nonpharmacologic and psychologic treatment modalities such as biofeedback and cognitive/behavioral therapy may be successfully used as part of a comprehensive treatment program to give patients a greater sense of control, reverse anticipatory anxiety, and improve functioning and quality of life in chronic recurrent headache.⁹ Muscular biofeedback has shown efficacy in chronic tension type headache (CTTH).¹⁰ Another study showed that biofeedback assisted diaphragmatic breathing and systematic relaxation produced a significant clinical response in 66.6% of migraine patients.¹¹ The effectiveness of biofeedback is related to a muscular relaxation and to its influence on NO bioavailability in patients with chronic migraine.¹²

Hypertension

Stress factors, especially high levels of occupational stress, potentiate hypertension. Several so-called psychological techniques including biofeedback have been applied to hypertension.¹³ Among biofeedback treatments, thermal feedback and electrodermal activity feedback fare better than EMG or direct BP feedback, which tend to produce null effects.¹⁴

A meta-analysis of 22 randomized controlled studies with 905 essential hypertensive patients showed that compared with clinical visits or self-monitoring of blood pressure (non-intervention controls), biofeedback intervention resulted in systolic and diastolic blood pressure reductions that were greater by 7.3 mmHg and 5.8 mmHg respectively. Compared with sham or non-specific behavioral intervention controls, the net reductions in systolic and diastolic blood pressures by

biofeedback intervention were 3.9 and 3.5 mmHg, respectively. The results suggested that biofeedback was more effective in reducing blood pressure in patients with essential hypertension than no intervention. Further studies will be needed to determine whether biofeedback itself has an antihypertensive effect beyond the general relaxation response.¹⁵

A study involving 8 weeks of relaxation training coupled with thermal, electromyographic, and respiratory sinus arrhythmia biofeedback in patients with stage 1 or 2 hypertension (78% taking BP medications) showed that the hypertensive patients not taking antihypertensive medication, having lowest starting finger temperature, and the smallest standard deviation in daytime mean arterial pressure, were likely to benefit most from biofeedback-assisted relaxation (BFAR) training and should be offered BFAR prior to starting hypertensive medications.¹⁶

Another study showed that biofeedback of the R-wave-to-pulse interval, a measure related to the pulse wave velocity, enabled participants with high blood pressure to achieve significant reductions of systolic (15.3 mmHg) and diastolic (17.8 mmHg) blood pressure levels from the beginning of the first to the end of the last training session.¹⁷

CAD

Biofeedback has shown promise in the management of coronary artery disease. A novel behavioral neurocardiac intervention, HRV biofeedback, can augment vagal heart rate regulation while facilitating psychological adjustment to coronary artery disease.¹⁸ Cardiorespiratory biofeedback increases heart rate variability in patients with coronary artery disease and therefore may be an integral tool for improving cardiac morbidity and mortality rates.¹⁹

Epilepsy

The treatment of epilepsy through operant conditioning of the sensorimotor rhythm electroencephalogram has a 35-year history. The clinical benefits derived from neurofeedback training, particularly in patients that are nonresponsive to pharmacotherapy, have been documented in many independent laboratories.⁶

In one study, EEG biofeedback was found to improve the cognitive and motor functions in individuals with greatest seizure reduction. Another study of EDR biofeedback reported significant reduction in seizure frequency.²⁰

Electrodermal (EDR) biofeedback has been shown to be highly cost-effective, discriminative for the actual level of stress and gives good therapeutic results through enhancing self awareness and relaxation, when used in combination with standard psychometric and psychotherapeutic methods for psychogenic non-epileptic seizures in pediatric patients.²¹

Recent advances in computer technology have resulted in the availability of relatively inexpensive high-quality equipment for the application of neurofeedback therapy, thus presenting a viable and promising treatment alternative to the interested clinician.⁶

Chronic Pain

A recent review of the literature on efficacy of psychophysiological approaches to assessing chronic pain problems and of biofeedback based interventions for treating them showed that different chronic pain conditions are differently amenable to psychophysiological assessment and biofeedback intervention. Each chronic pain disorder may have numerous underlying problems which result in very similar symptoms. Biofeedback is highly effective for treating pain due to jaw area muscle dysfunctions but not for problems in the joint itself.²² Biofeedback has shown positive results in fibromyalgia.²³

A study comparing older and younger adults in a multidisciplinary pain program indicates that older pain patients readily acquire the physiological self-regulation skills taught in biofeedback-assisted relaxation training, and achieve comparable decreases in pain for the pain program as a whole.²⁴

Constipation and Fecal Incontinence

During the past decade, significant strides have been made in the understanding and treatment of defecation disorders, which have led to real advances in the management of these disorders. Biofeedback therapy is one of these treatment modalities.^{25,26} Palsson, et al have reviewed the evidence showing that biofeedback is efficacious for constipation, fecal incontinence, anal pain, and other functional anorectal disorders. They found that the average probability of successful treatment outcome for patients treated with biofeedback was 67% for functional fecal incontinence and 62% for constipation.²⁷

Irritable Bowel Syndrome

Both visceral and cutaneous hypersensitivity exist in irritable bowel syndrome. MRI shows changes as compared to normal patients.²⁸ This coincides with another work combining EEG and peripheral biofeedback in the treatment of irritable bowel syndrome (IBS). Stress related IBS can be very effectively treated using behavioral interventions.²⁹

Bronchial Asthma

Preliminary research has found that biofeedback training to increase heart rate variability produces a decrease in respiratory resistance and improves spirometry performance in asthma patients. HRV tends to be reduced in patients with asthma and various diseases affecting the cardiovascular and/or CNS. HRV biofeedback may prove to be a useful adjunct to asthma treatment and may help to reduce dependence on steroid medications.³⁰

Diabetes Mellitus

McGinnis, et al showed that biofeedback and relaxation were associated with significant decreases in average blood glucose, glycosylated hemoglobin, and muscle tension compared with the control group. Further research is necessary to determine the long-term effects of biofeedback and the effects of mood on patients' responses to treatment.³¹

Miscellaneous

Biofeedback has been used in cardiovascular rehabilitation³² and post-stroke rehabilitation.³³ Recent advances in technology have resulted in the commercial availability of numerous force platform systems for the retraining of balance function in patient populations, including patients with stroke.³⁴ The results indicate that neurofeedback may represent a new promising technique in the therapy of chronic decompensated tinnitus,³⁵ may help early weaning patients on ventilator.³⁶ Role of biofeedback in dialysis, schizophrenia is being looked into.^{37,38}

Limitations or Side Effects of Biofeedback Therapy

There are no significant risks or side effects involved. The patients having a cardiac disorder should be evaluated before using heart rate variability training. The most commonly experienced side effect of relaxation training is drowsiness. Biofeedback therapy as a method for self-regulation can be a very effective tool for dealing with stress, but it is seldom adequate by itself for treating various forms of anxiety.

Prospects

Biofeedback is a promising therapeutic modality as it can reduce or even eliminate the need for medication and has the potential to help in conditions not responding to medications. Pioneering efforts have been made to develop and provide biofeedback services via a telehealth venue. Such capability would significantly improve access to care, particularly for patients located at considerable distance from the provider.³⁹ With technological advancement, biofeedback may

become a commonly used treatment modality all over the world in near future. However, the clinicians should be aware of the limitations of the biofeedback as considerable research is still needed for putting this on firm footing.

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