

## The surface electromyography biofeedback in pain management - theoretical assumptions and possibilities of using the method

**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.

**Streszczenie.** Zastosowanie elektromiograficznej metody biofeedback w leczeniu bólu może być bardzo przydatne w warunkach klinicznych. Dowody skuteczności metod opartych o trening funkcji psychofizjologicznych, w leczeniu bólu fantomowego, w obrębie kończyn górnych, dolnej części pleców, nie-sercowego bólu w klatce piersiowej oraz dolegliwości bólowych w obrębie miednicy mniejszej wymagają dalszych obserwacji klinicznych w celu ich szerszego zastosowania w leczeniu bólu o różnej etiologii (**Metoda biofeedback elektromiografii powierzchniowej w leczeniu bólu - założenia teoretyczne i możliwości zastosowania**).

**Keywords:** electromyography, biofeedback, clinical applications.

**Słowa kluczowe:** elektromiografia, biofeedback, zastosowanie kliniczne.

### Introduction

The use of the surface electromyography (sEMG) has many advantages because such recordings provide a safe, easy, and noninvasive method that allows objective quantification of the energy of the muscle. It is not necessary to penetrate the skin and record from single motor units to obtain useful and meaningful information regarding muscles. Patient can observe synergies in the energy patterns that cannot be seen 'normally'. The technique allows the observer to see the muscle energy at rest and changing continuously over the course of a movement. With the use of multiple sensor arrays, it becomes possible to differentiate how different aspects of muscles do different things.

By adding SEMG recording information to the practitioner's fund of knowledge about the muscle function of a particular patient, the practitioner begins to blend valuable information concerning how the nervous system participates in the orchestration of the muscle function.

Physiological information obtained via SEMG methods can be feedback to the patient, providing a basis for neuromuscular reeducation and for self-regulation. Such information can fine-tune the response of the patient's nervous system to the therapist's verbal instructions.

As the patient learns to recruit a particular muscle, the initial attempts may be compared to the current attempts. This type of information provides feedback and motivation for the patient's therapeutic efforts. It may also become an important source to demonstrate to third-party payers that the prescribed treatment is having the desired effect.

Biofeedback involves developing patients' ability to alter a particular physiological response by providing them with feedback about the response they are attempting to control [1]. Electromyography (EMG) is one of the most common types of biofeedback, which involves feedback of muscle tension (Fig. 1). Other types of biofeedback include thermal biofeedback, which provides information on skin temperature; electroencephalography (EEG), which provides information on brain wave activity and electrodermal response (EDR), which provides information on sweat gland activity.

Biofeedback training does provide subjects with information that enables them to control voluntarily some aspect of their physiology that may contribute to the pain experience [2]. However, because pain is a complex behavior and not merely a pure sensory experience,

biofeedback is most beneficial for patients when used as one adjunctive component of an interdisciplinary pain management program [3]. Using an electromyography during biofeedback sessions, a patient learns to reduce muscle tension in different areas that can cause increased pain. The electromyography equipment measures electrical activity in the muscles, which in turn reveals the degree of muscle tension.

### Case

44 year old body-builder who has been diagnosed with myelopathy, which was evaluated as moderate – grade III. Patients with cervical myelopathy can present a broad spectrum of signs and symptoms, depending on the magnitude of spinal cord dysfunction and chronicity. The leading symptoms are numb, clumsy, painful hands and compromised fine motor skills. Further signs are atrophy of the interosseous muscles, gait disturbance, ataxia, and symptoms of progressive tetraparesis.



Fig. 1. Longitudinal CT section of the cervical spinal cord.

### EMG Biofeedback training

Electromyographic biofeedback is a therapeutic modality used along with other interventions in the treatment of pain. A new design of therapeutic traction modality, based on EMG signals from selected muscles, was developed for rehabilitation. EMG biofeedback, utilizing the controlled therapeutic biofeedback machine (Nexus-4, MindMedia NL), was used to relieve neck pain (cervical compression syndrome). This modality included the main traction

controller, a high signal-to-noise ratio EMG scanning and processing unit, computer interface hardware, on-line self-adjusted traction force actuating unit, and biofeedback control software, presented to patient in the form of short animations and games. Biofeedback treatment was implemented as an auxiliary procedure, in addition to other physical therapy treatments and pharmacotherapy. Ag/AgCl surface electrodes, using polymer coatings, were applied during this procedure. The effect of pain reduction, measured as 3 points on the 5 points VAS scale, was gained after 20 biofeedback sessions.

Below are presented screenshots which were observed by the therapist during the treatment, showing the differences in muscle tension, observed on both sides of the back.

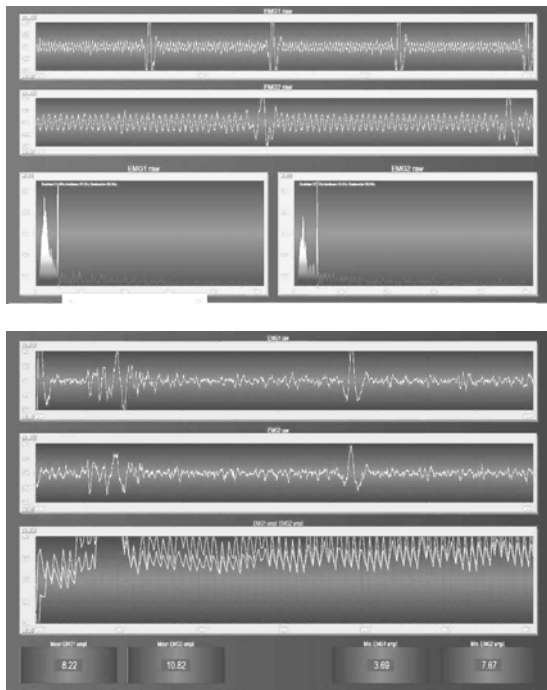


Fig. 2. Nexus-4 screenshots presenting muscle tensions. Surface EMG recordings from the cervical trapezius at rest. The higher image of the tracing was conducted using a 25- to 1000-Hz band pass filter (wide) while the lower was conducted using a 100- to 200-Hz filter (narrow). 100- to 200-Hz filter eliminated the ECG artifact, while the high image of the cervical trapezius showed a striking ECG artifact.

## Discussion

Many layers of muscles are present in the treated region. The scanning electrodes collected data from the upper fibers of the trapezius, the splenius capitis, the splenius cervicis, and the semispinalis cervicis. These muscles are primarily involved in the support and rotation of the head. With unilateral activations of these muscles, rotation or bilateral flexion of the head may occur. An extension of the head may occur with the bilateral activation.

In patients with poor posture, where head is held in front of its center of gravity, these muscles are required to provide chronic muscular support for the approx. 7 kg weight of the head. In such cases, these muscles become fatigued, and 100- to 200-Hz filter recording may not adequately represent the nature of muscular dysfunction.

In another common variation, the cervical muscles may appear to have very low EMG values, especially in comparison to trapezius T-1 or T-6. When this occurs, the cervical muscles are 'unloaded', transferring the work to these lower muscles. This pattern of activity is an inappropriate muscle synergy. Even though the cervical

muscles show low EMG values, Activations in related muscle groups make these values suspect. If evaluating this region, the practitioner should consider pattern analysis comparing one site to other sites.

The cervical muscles have been indicated in cervical pain, which is also located in the occipital and frontal regions of the head. There may be a concordance in activation between the frontalis muscle and the cervical paraspinal muscles.

## Conclusions

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 [4,5,6]. The biopsychosocial model of pain, which is now accepted as the most heuristic approach to the understanding and treatment of pain disorders, views physical disorders such as pain as a result of a complex and dynamic interaction among physiological, psychological, and social factors, which perpetuates and may worsen the clinical presentation [7,8]. Biofeedback can serve as one important modality in this comprehensive approach.

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