Effectiveness of Electromyographic Biofeedback in the Treatment of Musculoskeletal Pain

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Abstract

Electromyographic biofeedback is a therapeutic modality used along with other interventions in the treatment of pain. This article presents a brief review of the effectiveness of electromyographic biofeedback in treating musculoskeletal pain. Electromyographic biofeedback may provide pain relief for chronic musculoskeletal pain due to cumulative trauma, and may be proposed as an additional intervention to exercise in patellofemoral pain syndrome and acute sciatic pain. Electromyographic biofeedback is comparable to cognitive behavioral treatment and relaxation techniques. When added to an exercise program in patients with patellofemoral pain or acute sciatic pain, no further pain reduction is achieved. Electromyographic biofeedback promotes active participation and thus may motivate patients to adopt an active role in establishing and reaching goals in rehabilitation. Further research is required to investigate its effect on musculoskeletal pain.

The concept of biofeedback was developed in the 1960s, and research on human patients with particular pathologies or disorders began in the 1970s. Biofeedback is a method through which various biological processes of the body can be monitored, recorded, and potentially controlled by the patient undergoing treatment with the assistance of specialized equipment. These processes are usually involuntary or not easily or fully perceptible. They can be recorded with electronic equipment that translates the input to visual, auditory, or other cues. The patient may become aware of these autonomous functions and may attempt to influence or control them. The patient is trained to alter a given signal to a certain level through exercise or relaxation, thus approaching “normal” or the nearest normal levels. As a result, an objective interaction between signal and patient is created.

Electromyographic biofeedback is a specific form of biofeedback. The biofeedback device records muscle tension and tone through the application of electrodes superficially or subcutaneously. In the latter case, a needle is inserted when targeting specific muscles. Muscle tension is measured in microvolts. Tension is turned into a more easily perceptible stimulus or visual, auditory, or other cue, which varies as muscle tension increases or decreases. The patient therefore receives feedback from the device and is able to perceive and modify muscle tension, which usually ranges from 5 to 40 µv.

Prior to application, it is necessary to acquire baseline measurements to compare results with initial muscle tension levels. The goal of treatment is to train the patient to control the reduction or increase of muscle tension during exercise, a specific posture, or inactivity.

The effects of electromyographic biofeedback have been investigated in various pathologic conditions. Current literature on electromyographic biofeedback and its effectiveness in reducing chronic low back pain is unclear, as it has been sup...
ported to provide better results than back schools or other alternative methods and equal pain relief compared to cognitive behavioral treatment at 6 months following treatment. Hasenbring et al concluded that electromyographic biofeedback contributes to the reduction of sciatic pain and prevention of the transition of subacute sciatica to chronic sciatica. It is emphasized that when electromyographic biofeedback is proposed in the literature, it is proposed as a complementary treatment to back and leg pain, and in that way it may assist in reducing pain levels.

Electromyographic biofeedback has also been proven to be a useful therapeutic alternative for musculoskeletal injuries of the upper extremity. Three hundred nine patients underwent 12 sessions of electromyographic biofeedback, after which 96% reported that they felt “a lot better,” which indicates a general improvement relevant to quality of life. Regarding lower extremities, patellofemoral pain did not appear to decrease with the addition of electromyographic biofeedback to conservative treatment.

Reduction of muscle spasm may potentially lead to pain relief. Electromyographic biofeedback is most commonly used to control muscle tone and has been researched in spinal disorders. It has been reported to decrease the muscle tone of paraspinal muscles of the lumbar spine and assist in stretching. The findings of this study are of clinical significance, since muscle spasm is one cause of mechanical low back pain. In the study of Wong et al, mechanical traction was used with electromyographic biofeedback in the cervical spine. Paraspinal electromyographic activity decreased in both healthy patients and patients with cervical radiculitis.

Electromyographic biofeedback has also been found to decrease the muscle tone of the trapezius and the levator scapulae from 60% to 76% in various shoulder elevation degrees. Reduction of muscle tone may prove beneficial when muscle spasm is present in either muscle. Redistribution of loads in the shoulder region was also demonstrated, along with an improvement of the biomechanics of the region.

Electromyographic biofeedback is a promising therapeutic intervention. However, no comprehensive review regarding this interesting topic has been presented in the literature. In this article, the literature is critically appraised to investigate the role of electromyographic biofeedback in the rehabilitation of musculoskeletal pain.

Materials and Methods
Three electronic databases were searched (PubMed, EMBASE, PEDro) using the terms “electromyographic biofeedback” or “EMG biofeedback” and “pain.”

Inclusion criteria were patients presenting with musculoskeletal pain and random controlled trials. Exclusion criteria were patients with temporomandibular joint disorders, since the effectiveness of electromyographic biofeedback on these disorders has been recently reviewed, or headache, and pathologies or syndromes presenting with multiple locations of pain, eg, fibromyalgia.

Seven randomized control trials were retrieved and 5 met the CONSORT (Consolidated Standards of Reporting Trials) criteria for randomized control trials.

Results
The effectiveness of electromyographic biofeedback in reducing pain levels has been investigated in randomized controlled trials of patients experiencing pain due to chronic upper extremity cumulative trauma, chronic low back pain, sciatica, and patellofemoral pain syndrome. The Table summarizes the results in the following studies.

Spence et al investigated the effect of electromyographic biofeedback on pain in 48 patients with chronic upper extremity cumulative trauma with a 5- to 6-year history of pain. Electromyographic biofeedback was compared to relaxation training and a combination of electromyographic biofeedback and relaxation training. Outcome criteria were pain, distress, and interference in activities of daily living. Short-term pain relief was evident in the 3 treatment groups, mostly in relaxation training, and at 6 months pain had significantly decreased in all groups.

Newton-John et al studied 44 patients with chronic low back pain who were relatively well functioning, and compared electromyographic biofeedback with cognitive behavioral treatment. Pain intensity, levels of disability, adaptive pain beliefs, and depression were measured, with a follow-up of 6 months. Significant improvements were demonstrated at 6 months in both electromyographic biofeedback and cognitive behavioral treatment groups.

Hasenbring et al studied 50 patients with acute sciatic pain who were randomly assigned to 3 groups: electromyographic biofeedback, cognitive behavioral treatment, or usual care. Outcome criteria included pain intensity using a 0-to-10 scale, depression, pain-related physical dysfunction, return to work, and retirement due to pain. The follow-up extended to 18 months and results showed cognitive behavioral treatment to be more effective than electromyographic biofeedback, although electromyographic biofeedback was also effective.

Dursun et al focused on patients with patellofemoral pain syndrome (n=60) and compared electromyographic biofeedback training with a conventional exercise program to an exercise program. Outcome measures included maximum and mean contraction values of the vastus medialis and the vastus lateralis muscles with biofeedback, visual analog scale, and functional index questionnaire. Statistically significant improvement in visual analog scale and functional index questionnaire scores was demonstrated, but no significant difference between groups was observed. Mean contraction values of the vastus medialis muscles in 3 measurements conducted monthly and of the vastus lateralis muscles in the first month in the biofeedback group were statistically significantly higher than the control group.
Yip and Ng\textsuperscript{22} investigated the effect of electromyographic biofeedback on patients with patellofemoral pain ($n=26$). Patients were assigned to 1 of 2 groups: electromyographic biofeedback or exercise only. Both received an 8-week home exercise program of at least 15 minutes, including flexibility, strengthening, balance/propiroception training, plyometrics, and agility training. The electromyographic biofeedback group additionally received electromyographic visual feedback of the quadriceps muscle during exercise. Outcome criteria included isokinetic knee extension strength, perceived pain severity (patellofemoral pain severity scale score), and patellar alignments in 0, 4, and 8 weeks.

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Isokinetic peak torque increased in both groups \( (P=.005) \). There appeared to be a tendency toward pain relief \( (P=.088) \). Work output and patellar alignment also improved significantly.

**DISCUSSION**

Electromyographic biofeedback has been tested in clinical entities that are considered challenging in everyday practice, such as low back pain, with favorable results, which underlines the potential of electromyographic biofeedback for pain relief. Several features of the studies selected for this systematic review need to be mentioned.

Dursun et al\(^7\) used the visual analog scale and the functional index questionnaire to measure pain and function, respectively. Although both appear to be reliable, and the visual analog scale appears to be valid and sensitive to change, additional research is warranted on the functional index questionnaire.\(^5\) Therefore, the results provided by the functional index questionnaire may be considered with reservation. Furthermore, the authors acknowledge the need for a larger sample and longer follow-up.

Spence et al\(^9\) used small numbers of patients, thus undermining the statistical significance of the results. Furthermore, the inclusion criteria and clinical signs identified from clinical examination extended to patients presenting with different pathologies and locations of pain. Pain due to repetitive tasks in the workplace included various anatomical areas such as the entire upper limb, shoulder girdle, and/or neck. In that way, electromyographic biofeedback was applied to a heterogeneous sample, and therefore results are important but of limited value, since the treatment followed may not be proposed for a specific pathology based on this study.

Electromyographic biofeedback in this study was also applied to different anatomical areas throughout treatment, starting from forearm flexors and progressing to the trapezius muscles if pain was experienced in these areas. The change of anatomical location of treatment (electrode placement) throughout treatment is critical, since it is not reported when or whether changes occurred in each patient or groups of patients. There is no standard location of treatment within the 2 groups that used electromyographic biofeedback. This variability undermines the results of the study and the conclusions drawn from it, since there would be no specific protocol to be proposed should electromyographic biofeedback be proven effective.

A small sample was also selected by Newton-John et al\(^7\) suggesting the possibility of results of questionable significance. Thirty-two percent of patients received analgesic medication for pain, which constitutes a potential confounding factor affecting the results of the study, since no details are provided. Receiving medication may have started a few days before the trial or may have stopped during the trial, therefore having positive and negative effects, respectively, on the outcomes of a part of the sample. No electromyographic recordings were conducted, as it was not considered an outcome criterion. Consequently, the relationship of electromyographic recordings to various pain questionnaires cannot be investigated, which could lead to notable conclusions.

The rationale of the treatments offered and the electromyographic biofeedback protocols in the studies by Spence et al\(^9\) and Newton-John et al\(^7\) are different from protocols in the other studies, since rehabilitation incorporates training to reduce muscle tension levels in different environments and external stimuli such as stressful situations, physically demanding tasks, imagination, or role playing. Therefore, a strong psychological rehabilitation component is included, whereas in other studies treatment focuses on the specific muscle or muscle group and functional rehabilitation. This approach should be encouraged, since rehabilitation should not only address the physical deficiencies and their treatment, but also the effect of psychological parameters on the body.

Hasenbring et al\(^8\) used the avoidance-endurance model of pain chronification to separate high-risk from low-risk patients; thus, assigning patients to groups was not entirely random. Furthermore, cognitive behavioral treatment was administered to the groups based on the avoidance-endurance model. Consequently, cognitive behavioral treatment in this study was different from that in other studies, and this element should be kept in mind when comparing the effect of cognitive behavioral treatment as provided by Hasenbring et al\(^8\) to cognitive behavioral treatment provided in other studies. Identifying high-risk and low-risk patients occurred because the purpose of the study included preventing the progression of acute sciatic pain to the chronic stage.

In a trial by Yip and Ng\(^2\) a sample of 26 patients performed a protocol consisting of either electromyographic biofeedback with home exercise of at least 15 minutes or exercise alone. The treatments occurred at the patients’ homes following patient education. It is reasonable to assume that home treatment is likely to vary in duration across patients and application may not be appropriate compared to supervised treatment. Therefore, differences in treatment may lead to a nonstandard intervention resulting in altered results.

Function was either not addressed or, when investigated, improvement in function was not associated with biofeedback training, as in the study of Dursun et al\(^11\). Addressing functional recovery in electromyographic biofeedback randomized controlled trials is necessary to investigate the significance of electromyographic biofeedback in the rehabilitation process.

It is essential to acknowledge the role of confounding factors in research regarding electromyographic biofeedback. Patient participation is a critical factor for the outcome of treatment. The patient at the specific time of treatment might be distracted, or the environment where the session is taking place might not be appropriate to ensure relaxation and concentration. Therefore, biofeedback sessions are
less likely to assist in pain relief due to the reduced participation of the patient.

The selection of electrodes is another issue to be considered, since electrodes from different materials may demonstrate and record different signals due to artifacts produced during electromyographic application. The studies presented either did not report the type of electrodes used or used different types of electrodes among studies. Thus, there may be errors in the measurements of electromyographic activity that may have influenced results variably.

Pain is subjective and is experienced differently by different people. Its subjectivity is a challenge for the validity and reliability of outcome measures of quantitative studies and undermines the rigor of studies. Electromyographic biofeedback can make the patient feel more in control of the experienced pain, since there appears to be a way to influence and thus reduce pain levels. Thus, biofeedback promotes active participation and motivates the patient, which is arguably the most critical element for pain management.

Research directly comparing the effects of biofeedback and physical agents on pain is scarce. Future research might explore and compare the effectiveness of each, since several physical agents (eg, transcutaneous electrical nerve stimulation) are widely used for pain relief.

It is evident in all studies presented that electromyographic biofeedback, often in conjunction with other interventions, provided significant pain relief. However, electromyographic biofeedback failed to reduce pain to lower levels than other treatments used, such as cognitive behavioral treatment, relaxation training, and exercise. Although further research is required to investigate the effectiveness of electromyographic biofeedback on musculoskeletal pain, current literature portrays electromyographic biofeedback as a promising intervention in pain management.

Future studies could include larger samples to ensure the significance of results, and follow-ups longer than 6 months could be used to investigate the long-term effectiveness of electromyographic biofeedback. Research could also focus on specific conditions rather than general pathologies such as cumulative trauma disorders. In that way, treatment plans for specific pathologies may be developed.

Electromyographic recordings are proposed to be selected as an outcome criterion, since a comparison of an electrical correlate of muscle tension to functional status, disability, or even quality of life will be possible, which might lead to co-relations of a physical measurement (electromyographic values) to a psychophysiological variable (eg, functional status).

REFERENCES
