Biofeedback
In Neuromuscular Rehabilitation

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Objectives

- Define Biofeedback and the significance of its use in the clinical setting.
- Explain electromyography and its physiologic role in the measurement and decoding of electrical activity.
- Describe the specific clinical uses of biofeedback in injury rehabilitation.
- Show the components of biofeedback machines and their role in the treatment procedure.
- Outline the setup and administration of biofeedback on a patient.
- Identify different types of biofeedback machines and electrodes.
- Express the advantages and disadvantages of biofeedback use in rehabilitation.

What is Biofeedback?

- Biofeedback is a therapeutic modality that uses electromyography to monitor the body’s electrical activity and express it in a way that the patient can view their own progress.
- Electrical activity enters the machine and is expressed through visual or auditory means that can be observed by an athlete, bridging the mind-body connection.

Electromyography (EMG): The Foundation of Biofeedback

- Muscle contraction begins at the motor unit when a depolarization threshold at a nerve is reached and the neurotransmitter acetylcholine (ACh) is released. 2, 5, 6, 7

- This voltage change at depolarization is detected by electrode pads that lead to the biofeedback machine that decodes the signals. 8

- While the processing and display of information is the most crucial part of biofeedback, there is no universal procedure for quantifying information between different manufacturers and machines. 7
Electrodes placed on the skin detect both electrical and non-electrical (extraneous) activity. These signals must be manipulated by the machine to make them visible to the patient. Biofeedback electrodes have two active and one reference electrode, which is typically placed in-between the two active pads. Signals from the active pads are sent to a "differential amplifier," which separates extraneous and electrical signals and amplifies the electrical signals. Once the electrical signal has been separated, it becomes a raw voltage, which is smoothed into a quantifiable signal that can be viewed by the athlete.

Depending on the type of machine, signals are represented with sounds, vibrations, or visual stimulus to the athlete.

Electromyography detects all electrical activity, not just muscle contraction. This is significant in the early stages of post-surgical rehabilitation when visible muscle contraction can not always be seen.
The Significance of EMG in the Clinical Setting

- Biofeedback is significant in the psychological aspects of injury rehabilitation, and can encourage rehabilitation efficacy. 4, 5
- During ACL rehabilitation, electrodes can be applied to the vastus medialis oblique while exercising so the patient can monitor their progress throughout the rehabilitation process.

Clinical Applications of Biofeedback

- There are three significant roles of biofeedback for the use of rehabilitation
  - Muscle Re-education
  - Relaxation of Muscle Guarding
  - Pain Reduction

The Use of Biofeedback for Muscle Re-Education

- Biofeedback assists in isolating a specific muscle and measures its contraction individual to other muscles (e.g., when contracting the quadriceps muscle group, the hamstrings are often subconsciously contracted. Biofeedback can differentiate between the contractions). 3, 7
- Muscle re-education is performed by progressively increasing isometric contractions that last for 6-10 seconds each by adjusting the sensitivity of the machine as the athlete improves. 8
- Biofeedback is significant in testing muscles that are not functional enough to be evaluated in manual muscle tests. 6
The Use of Biofeedback for Muscle Guarding

- Biofeedback expresses muscle activity that an apprehensive athlete may not be able to recognize without visual/auditory feedback.
- A patient will gradually increase contractions as their pain is reduced, which gives them security in their movements and encourages them to do more.
- Increasing sensitivity and moving electrodes further apart during a session will stimulate an athlete to improve contractions.

The Use of Biofeedback for Pain Reduction

- Biofeedback reduces pain by relaxing tense muscles.
- Relaxation of muscles helps interrupt the pain-spasm cycle, which allows the athlete to both increase muscle contraction and move with less pain.
- Biofeedback works psychologically against pain because visual feedback encourages progressive relaxation.

The Significance of Biofeedback in Surgery Rehabilitation

- Biofeedback helps in post-surgery rehab because it works psychologically to establish long-term effects.
- Post-surgically, biofeedback initiates voluntary muscle control, which leads to better progression through later stages of rehabilitation.
- Specific to Anterior Cruciate Ligament (ACL) reconstruction rehabilitation, biofeedback helps to isolate muscles and regain control in the first 2-4 weeks.
The Application of Biofeedback

- Patient Preparation:
  - The patient can be sitting, standing, or lying down depending on the goals of treatment.
  - The Therapist facilitating the session should demonstrate biofeedback on himself/herself first to guide the patient. 6

- Skin Preparation:
  - The area of treatment should be shaved if necessary. 8
  - The area should be scrubbed with an alcohol pad to remove dirt, oil, and dead skin. 8

All about Electrodes

- While electrode sizes vary, increasing the electrode size will not amplify the electrical signal. 6
- A conductive gel or other medium should be applied to the electrode to increase signal detection. 5, 8

All about Electrodes (Continued)

- As biofeedback machines will differ, so will electrodes. Newer models of electrodes (shown below) contain both active and reference electrodes on the same pad to ensure proper application.
All about Electrodes
(continued)

- Electrodes should be placed parallel to the direction of the muscle being tested, with the reference electrode placed in-between the active pads.

- Electrodes should surround the smallest area possible to detect electrical activity as accurately as possible.

- Electrodes should be secured to the body part with an elastic or non-conductive wrap to minimize excess movement of the pads that will increase extraneous signals.

Application of Biofeedback

- Biofeedback machines detect information according to the designated sensitivity level set on the machine. The lower the sensitivity level, the lower the amount of muscle activity needed to give feedback.

- A patient progresses by increasing sensitivity levels as a patient becomes stronger and more aware of his voluntary contractions.

- The operational procedures are unique to each machine, and should be followed accordingly throughout each session.
Types of Biofeedback Machines

Advantages and Disadvantages of Biofeedback
- Voluntary psychomotor control of activity is a significant beneficial aspect of biofeedback.\(^1\),\(^3\),\(^5\)
- Prentice and Voight state that “Perhaps the biggest advantage of biofeedback is that it provides the patient with a chance to correct small changes in performance that are immediately noted and rewarded so that eventually larger changes or improvement in performance can be accomplished” (Page 305).\(^2\)
- One disadvantage of electromyographic biofeedback is the training and guidance required by the therapist to facilitate the first few treatment sessions.\(^4\)

Review Quiz
1) Electromyography is based on the detection of:
   - a) muscle contraction
   - b) firing of a motor neuron
   - c) strength of electrical stimulation placed on the body
   - d) sensitivity of electrodes
   CORRECT: B

2) Non-electrical activity detected by biofeedback electrodes is also known as:
   - a) active electricity
   - b) inactive electricity
   - c) extraneous activity
   - d) inactive signals
   CORRECT: C
Review Quiz

3) The signals manipulated and expressed to the patient by the biofeedback machine are:
   a) electrical signals
   b) non-electrical signals
   c) raw signals
   d) raw voltage
   CORRECT: D

4) Biofeedback has been shown to:
   a) reduce muscle guarding
   b) reduce muscle pain
   c) assist with muscle re-education
   d) all of the above
   CORRECT: D

5) Biofeedback assists in muscle re-education in the first _____ of ACL reconstruction post-surgical rehabilitation:
   a) week
   b) 2-4 weeks
   c) 4-6 weeks
   d) biofeedback should not be used in post-surgical rehabilitation
   CORRECT: B

6) Which of the following is NOT a necessary preparation technique for a biofeedback session:
   a) apply conductive gel to the electrodes
   b) shave the treatment area if there is only a small amount of hair
   c) have the athlete lie down
   d) demonstrate the procedure on yourself before applying it to the athlete
   CORRECT: C

7) Which of the following is the biggest advantage of biofeedback?
   a) regaining voluntary muscle control
   b) isolating muscle contraction in post-surgical rehabilitation
   c) the athletic trainer’s role in guidance of the athlete
   d) psychological encouragement throughout rehab
   e) both a & d
   CORRECT: E

8) What is insignificant about electrodes when performing biofeedback rehabilitation?
   a) electrode size
   b) electrode location
   c) the application of a conductive gel to the pads
   d) clean electrodes
   CORRECT: A
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