

HIGH-TECH HEALING

Comparing biofeedback to electrical muscle stimulation in athletic rehabilitation

I have been involved in evaluation and treatment of sports medicine injuries for over 33 years. I've been very fortunate to have a "true" sports medicine practice that predominantly includes professional, college, high school, amateur and aging athletes.

Treating this clientele has forced me to explore and pursue restoring full function in the timeliest manner, being very careful to not cause further harm by using an aggressive approach.

Attacking Neurological Deficit

One secret to successful return to sports with minimal adverse effects is fully restoring muscle function. Although many aspects of our field have seen excellent advancements and growth, we continue to combat one of the most difficult challenges following injury and surgery — muscle atrophy and weakness.

Restoring muscle function should not only be measured by muscle force output and scores obtained on functional tests, but neurological function. In my practice, establishing normal neurological function following knee surgery is the primary goal on the path toward successful return to function.

Biofeedback is my preferential method of attacking the neurological deficit following surgery or injury. New advances in clinical products have allowed the ability to provide a general assessment of the patient's EMG neurological status. Subjects' ability to fire the inhibited muscle may now be conveniently measured by recording EMG activity of the involved extremity and comparing it to the opposite, normally functioning muscle group.

The primary rationale for biofeedback is the belief that the patient should begin to use their own "electrical system" as soon as possible through volitional contraction. The concept known as "order of recruitment" lends support to biofeedback to enhance volitional contraction. This order is based on Henneman's size principle, which states that under load, motor units are recruited from smallest to largest.¹

In practice, this means that slow-twitch, low-force, fatigue-resistant muscle fibers are activated before fast-twitch, high-force, less fatigue-resistant muscle fibers. When using a biofeedback device, the clinician sets the goal for the inhibited muscle so that a strong voluntary effort is required by the patient for each contraction. This is visible to the



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patient and forces a strong contraction to reach the preset goal. I believe that voluntary contraction using biofeedback produces the greatest results in restoring muscle function early.

Supporting Evidence

Electrical muscle stimulation is often used to stimulate muscle contraction. A vast amount of literature supports EMS during rehabilitation. Until recently, EMS has been a reimbursable modality; thus, there was much financial support to research its effectiveness. Biofeedback has not been reimbursable, which may have affected the comparative lack of literature.

One article supports biofeedback over EMS. This study compared the two modalities during ACL rehabilitation. After 6 weeks, the biofeedback group showed greater quadriceps isometric muscle strength than the EMS-treated group.² I believe in using EMS if a patient is unable to make any voluntary contraction, which sometimes happens following ACL reconstruction surgery.

Once a patient is able to produce a voluntary contraction, detected through biofeedback, we immediately switch the patient to biofeedback. When using EMS, all nerve fibers are stimulated simultaneously.³ This, in my opinion, is not as effective as biofeedback, because the order of recruitment from small- to large-diameter nerve fibers is not sequential as is the case with voluntary contraction.

EMS actually recruits the large-diameter nerve fibers first because they are more excitable, as large-diameter axons have lower resistance to firing.³ Atrophy of muscles has predominant effects on the slow-twitch, smaller-diameter Type I fibers, so recruiting these muscle fibers is critical to reverse the effects of muscle inhibition and atrophy.

I use biofeedback on virtually every knee patient who displays decreased neurological EMG output. A new device allows side-to-side assessment of EMG activity. This information is both educational and motivational to the patient as they can see the actual deficit via visual EMG numbers.

Cycles of 10 seconds on and 10 seconds off are utilized during the 10-minute session. My instructions to the patient for quadriceps re-education are to "tighten your muscle and force your knee straight." Progress is monitored weekly to measure the change in EMG activity.



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The unit we use employs an amplifier that sends measured EMG activity via Bluetooth signal to an Android or IOS device with the appropriately downloaded software application. Patient motivation is high as they can actually visualize the intensity of muscle contraction during home exercise programs. There seems to be an interesting psychological connection between the use of one's personal smartphone or computer pad and their muscle activity.

Practical Uses

Lack of extension of the knee has been shown to have an adverse effect on knee function. Loss of extension alters the gait pattern and can produce abnormal stresses to the patella-femoral joint. Biofeedback can combat this common malady often associated with post-op care of the knee.

Due to a lack of quadriceps control, many quad-inhibited patients ambulate with a flexed-knee gait pattern. Lacking quad control, patients are unable to eccentrically control the knee flexion moment during single-limb balance. A quad-inhibited patient will assume this flexed knee position because they "know" the position of the knee during single-limb balance.

This sets up the knee for a co-contracted state and presents as muscle splinting until normal muscle tone and function are restored. This muscle splinting will continue to exacerbate the lack of extension in the knee.

Biofeedback can be very effective at addressing this issue. With muscle splinting, we want to teach the patient to relax the hamstring muscle during knee extension stretching, thus negating the effect of a contracting hamstring muscle. The patient is placed in a prone position, with both patellae over the edge of the table. Electrodes are placed over the hamstring muscle.

Unlike the inhibited quadriceps muscle, where we try to elicit a more perfect contraction, the biofeedback unit is now used for relaxation purposes. As the patient uses the relaxation mode of the unit and learns to

control the overly active hamstring contraction, an immediate increase in passive knee extension is observed. This position is maintained for a 10-minute period.

Once the patient has "learned" to control the hamstring overactivity, a small (2-pound) weight may be applied for the 10-minute period. Change in knee extension can be measured using heel-height difference. Dale Daniel described this measurement and showed that 1cm of HHD equals 1 degree of flexion contracture.⁴

Early Steps to Rehab

There are many obstacles when assisting your athlete to the ultimate goal: returning to sport with pre-injury level of performance. Too often, a shift is made during rehabilitation to more functional activities and reduced emphasis on strengthening.

If your patient continues to possess a decreased EMG signal compared to the normal side, it's very unlikely he will be able to resume a pre-injury level of function. With new advanced biofeedback, we know that we have completed one of the early critical steps in rehabilitation — restoring and measuring normal neurological function of the inhibited muscle group.

Don't let decreased EMG function be one of the obstacles to linger. ■

References

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