EMG Biofeedback: What Can it Actually Show?

Lee Herrington

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Electromyography, biofeedback, muscles.

Over recent years electromyography (EMG) biofeedback units have become more widely available to physiotherapists and success has been reported in the literature with their use in treating certain musculoskeletal conditions (Wise et al., 1984). This paper intends to review EMG briefly, describing what it is and how it can be interpreted and in the light of this what EMG biofeedback is capable of demonstrating with regard to the activity of the muscles examined.

EMG is a method of recording and quantifying the electrical activity produced by the muscle fibres of activated motor units (Sale, 1992). It is the actual depolarisation and repolarisation of the surface membrane of the muscle fibre which is the source of the electrical potential changes detected (Clarys and Cabri, 1993). The EMG signal recorded can be significantly affected by physiological parameters such as motor unit recruitment, intervening fatty tissue, muscle temperature, muscle cross-sectional area and length. Electrode type, size, location and spacing as well as the amplification and filtering processes can also alter the signals detected (LSUMC, 1995). The signal therefore is only an approximation of the actual myoelectric activity and does not necessarily represent the number and firing frequency of the involved motor units accurately (Turker, 1993).

The collection system for EMG signals consists of electrodes (surface or needle), amplifiers, filters and an acquisition device) now usually a micro-computer). The majority of work carried out by a physiotherapist will involve the use of a surface electrode (SEMG). Surface electrodes have a fairly large detection area, detecting signals from many motor units. This results in a number of disadvantages, for example their use is limited to superficial muscles; they are not selective enough for small muscles in the proximity of larger muscles and are prone to cross-talk and movement artefacts (LSUMC, 1995). The usefulness of SEMGs is limited to providing information on the time of activation and signal magnitude of the muscle under examination.

EMG data are usually recorded by computer. Here the sampling rate of the system is significant (Turker, 1993) and to record the highest SEMG components a sampling rate of 1,000 Hz or higher is required. If this sampling level is not met then the recorded data can become distorted (Turker, 1993). The raw data (raw EMG) then obtained need to be quantified by either rectifying and smoothing or integrating; these mathematical processes are described elsewhere (LSUMC, 1995). This qualification of the raw EMG signal is necessary in order to compare results or activity levels (Clarys and Cabri, 1993).

Interpretation

SEMG can provide only a close approximation of the level of myoelectrical activity and does not necessarily represent the number and firing frequency of the actual motor units involved (Turker, 1993) and if muscles are monitored during movement, activation levels and recruitment patterns can be depicted (Ng et al., 1996). Increased EMG activity has been shown after strength training (Sale, 1992) – that is, signal amplitude has increased; it is not possible (with existing knowledge) to imply that the force being produced is greater (Clarys and Cabri, 1993). The only interpretation possible is that increased EMG activity implies greater tension being generated (Selfe, 1995), with corresponding increases in the number of motor units firing.

When examining two independent EMGs from different muscles, it is not possible to state that because the signal amplitude, integrated value or some other measure of muscle A is greater than the corresponding measure for muscle B, that muscle A is producing more force than muscle B (Clarys and Cabri, 1993). The ability to make a direct comparison of that nature in this situation is complicated by many factors, ranging from the size of the muscle fibres involved to the nature of the interface between skin and electrodes (LSUMC, 1995).

Much interest in musculoskeletal rehabilitation has recently been focused on the achieving of 1:1 ratios of muscle activity, principally vastus medialis oblique: vastus lateralis in patello-femoral dysfunction (McConnell, 1994) and
lower fibres to upper fibres of trapezius in shoulder impingement. From the information given above it becomes apparent that comparing absolute EMG signal amplitudes is not a straightforward process. The only way a direct comparison between different muscles' EMG activity values can be made is if these values are expressed as a proportion of that muscle's normalised activity (Turker, 1993). The most reliable and reproducible method of normalising individual muscles' EMG data has been to use a maximal isometric voluntary contraction (MIVC) (Knutson et al., 1994).

**EMG Biofeedback Units**

The majority of commercially available units are capable of sampling a muscle's EMG activity only between 20-50 Hz (samples per second), whereas most researchers in the field of EMG recommend sampling activity at a minimum of 1,000 Hz to be acceptable (LSUMC, 1995). The majority of EMG biofeedback units are therefore providing only one-twentieth of the information regarded as at a scientifically acceptable level to ensure all components of the EMG signal can be recorded (Ng et al., 1996). Furthermore, the information they do provide is not processed but remains as the raw EMG signal containing any and all electrical noise and muscle cross-talk also detected, that is the natural background and other muscles' electrical activity are picked up and not filtered or processed out, possibly distorting the signal observed.

An EMG biofeedback unit seems capable of providing information on the time of activation and an approximation of the signal magnitude, not being able to accurately detect absolute activity and certainly not at present between muscle comparisons without further quantification of the data produced. The EMG biofeedback unit could therefore be a useful tool in the assessment of the relative timing of a muscle's involvement in a movement and the approximate level of muscular activity. This information in a treatment setting, allows the monitored muscle's activity level to be consciously manipulated during particular movements or static postures, through the use of feedback about its activity level.

**Common Faults in EMG Interpretation**

1. Because the amplitude of muscle A is greater than muscle B, it must be generating greater force, but all that can be ascertained from this information is that there is a greater amount of myoelectrical activity being generated by muscle A. Many factors can affect the level of activity recorded, as have been described above.

2. It is often assumed that because the ratio of activity of muscle A is equal to that of muscle B they are generating an identical force. This is especially true with the use of EMG biofeedback, where a force couple between the two muscles is then said to be in balance as the activity levels measured are equal. There are two faults in interpretation here; the first is explained above. Secondly, if those data are then compared to the MIVC, ie the data are normalised, it might be found that the activity level for muscle A is equal to that of 75% of its MIVC and muscle B is at 10% of its MIVC. The level of relative activity is not equal. Moreover, if it is being claimed that muscle A is working tonically to stabilise a joint (Richardson and Jull, 1995), it will not be able to maintain this level of activity long until it is subject to fatigue. Furthermore, working the muscle at greater than 40% MIVC may lead to the recruiting of inappropriate synergists (White and Sahrmann, 1994). Similarly, though muscle A is generating a greater proportion of its MIVC than muscle B, muscle B might still be regarded as dominant within the coupling, as any increase in activation required to overcome increased resistance for example can be met by B but is unlikely to be met by A creating an imbalance within the force couple.

EMG biofeedback is certainly a useful adjunct to treatment (Selfe, 1995) and has been employed successfully in treatment of a number of conditions, notably the patellofemoral pain syndrome (Wise et al., 1984). However, it has to be used with care, because of the limitations of the equipment itself and the potential errors when interpreting the true meaning of the level of EMG activity displayed. The actual signal produced can be used only to demonstrate the time of activation and in the grossest form the amount of EMG activity of a given muscle. It cannot be used for direct between-muscle comparison or in any way to describe the amount of force being generated.

It has been the intention of this brief review of EMG biofeedback not to discourage therapists from its use, as it has already been successfully applied in the treatment of both hypo- and hypertonicity in both neurological and musculoskeletal patients. Rather, it has tried to highlight the limitations of the data these units can present, and start an informed debate about the use of EMG biofeedback and if it does demonstrate what the clinician believes it to be showing about a particular patient's performance.
Author
Lee Herrington BSc MCSP is a private practitioner, studying for an MSc in sports injury and therapy at Manchester Metropolitan University.

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Address for Correspondence
Mr L Herrington, Glossop Physiotherapy and Sports Injuries Clinic, 88 High Street West, Glossop, Derbyshire SK13 8BB.

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