Clinical Neuromuscular Re-education with Biofeedback

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Clinical electromyographic biofeedback (EMGBF) was an outgrowth of diagnostic electromyography and my research on the fine control of motor units. In rehabilitation, EMGBF has gained a firm place in the treatment of upper motor neuron lesions particularly in retraining muscles and including relaxation of spastic muscles of stroke patients. In cerebral palsy and musculoskeletal disturbances, additional feedback transducers (e.g., electrogoniometers, pressure-sensitive and position-sensing devices) are gaining wider use. Spasmodic torticollis has proved to be particularly suitable for behavioural methods of treatment, including EMGBF.

Three main scientific sources flowed together to form the broad stream that is modern biofeedback; (1) electromyography, (2) electroencephalography, and (3) cardiovascular research by psychophysiologists. While the second and third streams are important, their influence on rehabilitation has been limited. Even in the adolescent period of electromyography, in the 1940's, we used the sound of motor unit potentials to grade the desired strength of contractions and often recruited the help of the patient.

In the more mature 1950's and early 1960's, my group was employing feedback signals to train exquisite controls in normal muscles of handicapped persons to substitute for lost limbs and to augment the strength of weakened parts of the body. Our concerns were twofold: first, to determine and define the normal mechanisms of motor control in all parts of the body, and then to develop methods and improve devices for treating neurologically and orthopedically handicapped patients.

Throughout the 1960's and 1970's, many investigations of a highly technical nature were reported around the world, giving EMGBF a solid foundation.

MUSCLE RELAXATION THERAPY

The main spinoff of our early EMG biofeedback studies undoubtedly has been relaxation therapy, in which the subjects and the trainer/therapist follow the progress of general body relaxation for monitor sampling electrodes (usually on facial muscles, e.g., the forehead areas). This training stimulated thousands of clinicians on several continents - mostly psychologists and psychiatrists - to apply feedback to the relief of various symptoms of stress. Tension headache, chronic back problems, and anxiety are prime targets, and the literature on their management with biofeedback relaxation is expanding rapidly.

BIOFEEDBACK IN REHABILITATION MEDICINE

Although EMG feedback is the dominant technique in rehabilitation, a number of other approaches to feedback therapy are quietly gaining recognition: limb-load monitors, head-position monitors, and electrogoniometric feedback.

Technical considerations

Equipment. Most EMG biofeedback devices on the market today were designed for psychotherapy, but they are practical in most rehabilitation settings and they are cheaper than several excellent special computerized devices; they will continue to dominate the field. They have one-channel or two-channel inputs, bipolar surface electrodes for each channel, excellent differential amplifiers, and some form of semi-integration of the signals. The raw EMG signal is processed to give a rising and falling voltage, usually with variable time-bases provided. This voltage then acts upon simple visual and acoustic output devices rather than on the type of outputs (e.g., cathode ray oscilloscopes) familiar to the diagnostic clinician. These include microvoltage meters, digital displays, threshold setters, banks of light, and sound transducers that produce noises such as clicks, warbles, and buzzes. Patients require very little training to "understand the signals produced. Also, the outputs can be fed into auxiliary devices for further functions, including computation.

Strategies. Therapists soon discover the EMG feedback is an adjunct to their skilled activities. Given clinical knowledge and competency in treatment of a specific ailment, reasonably good equipment, and some training and experience, a therapist molds the new approach into the total therapeutic plan.

Stroke therapy

In the 1970's we and a number of medical research groups began report

ing the efficacy of training the motor functions of a substantial proportion of previously "untreatable" patients. We found patients are able to discover within themselves the use of motor pathways that apparently have survived injury and have lain dormant. No other disorders of movement and posture are also proving to be treatable.

In rehabilitating stroke patients with biofeedback, three major symptom complexes have been the targets: footdrop (with or without spasticity), shoulder subluxation, and reduced hand function. The treatment of footdrop is emphasized here because it has had the widest application around the world. Our increasing success in treatment of the hemiplegic hand is also noteworthy.

Neural pathways

The neural pathways involved in marked neuromotor improvement are unclear. There are two possibilities: either new pathways are developed (highly unlikely), or old persisting cerebral and spinal pathways can be mobilized by introducing the auxiliary feedback loop. The latter explanation is highly probable.

What is true of retraining paralysed muscles is apparently also true of voluntary inhibition of spastic muscles. In patients with diseases and injuries of the central nervous system, the normal inhibition pattern is lacking, so that mass responses from local stimulation of the motor nerve cells in the spinal cord result in an exaggeration mass response described as spasticity.

The inhibition pattern would seem to come, in part, form obscure processes in diffuse centres of the cerebral cortex. Stroke patients who succeed in inhibiting marked peripheral spasticity apparently use surviving pathways that increase the inhibition of overactive spinal centers. By using an "override mechanism," they must be succeeding in damping even the influence of the powerful reflexes otherwise unrestrained.

Other applications

Spasmodic torticollis and related conditions. Substantial successes are attributable to EMG feedback. Other dyskinesias and dystonias also have been treated successfully.

Cerebral palsy. EMGBF in different areas of the body for cerebral palsy patients has had limited application, with no major controlled studies, but a number of electronic devices have been described that feedback information (usually acoustically) on body position or movement, e.g., in cerebral palsy patients, both head position monitors and foot placement and pressure switches are providing practicable.