BIOFEEDBACK IN PHYSICAL MEDICINE AND REHABILITATION

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INTRODUCTION

Muscle, or electromyographic (EMG), biofeedback refers to the use of electronic instrumentation to make covert muscle activity obvious to the patient through the display of visual and auditory representations of muscle contractility from within the pick-up radius of surface or indwelling electrodes (Wolf, 1978). This form of feedback is used by many practitioners engaged in relaxation training to reduce hyperarousal behavior. Under most circumstances in which general relaxation is sought through application of EMG biofeedback, the magnitude of change in measurable integrated muscle activity is comparatively small, often under 20 μV (microvolts). On the other hand, when muscle biofeedback is applied to patients with specific musculoskeletal or neuromuscular pathologies, appropriate sensory-motor functions and hence, coordinated and meaningful movement patterns, require electromyographic changes often exceeding hundreds of microvolts. In addition, unlike the results from feedback applications designed to re-establish homeostatic mechanisms within other physiological systems (for example, improve peripheral blood flow or systolic-diastolic differentials or alter heart rate), muscle biofeedback produces outcomes that are obvious even to the casual observer. Thus, while feedback of a cardiovascular activity might improve psychophysiological measures related to hypertension, often the attainment of self-regulatory control is unappreciated by clinician or patient. Feedback to re-educate abnormal movement behavior, however, will always result in a functional behavior that
is visible and easily quantified. Invariably, these elements contributed to the prediction by Fernando and Basmajian (1978) that, with respect to physical rehabilitation, "EMG feedback techniques will become routinely used" and "... EMG biofeedback has provided a major impetus for the advance of our body of knowledge for treating neurological dysfunctions."

Why should EMG biofeedback permit substantial functional improvement to occur among chronic neurological patients whose conditions have stabilized or remained unresponsive to conventional rehabilitation procedures (Brudny et al., 1979; Wolf, Baker, & Kelly, 1979)? The application of any neuromuscular facilitatory technique designed to re-educate weakened or paralytic muscles usually necessitates interfacing the clinician between stimulus and response. Following a command or instruction, the clinician observes the patient or palpates an appropriate body segment. Immediately following the patient's response, the practitioner assesses performance and "feeds back" a verbal instruction to the client. At best, this sequence takes a few seconds and, even when a premiere clinician evaluates a patient's movement activity, her subsequent command is comparatively non-specific.

On the other hand, muscle biofeedback provides continuous, uninterrupted and precise information about muscle activity delineated by the pick-up area of recording electrodes and by the properties of the feedback equipment (that is, signal-to-noise ratio, amplification, etc.). Therefore, specificity of the content and immediacy of the feedback distinguish machine from clinician, and for learning (or relearning) of any motor skill ongoing cerebral processing of activity, also called knowledge of results is essential (Howson, 1976). The central nervous system's remarkable capacity for processing audio and visual representations of muscle activity in a meaningful temporal and spatial manner to ultimately improve sensory-motor integration probably accounts for the success of this modality among many rehabilitation patients.

The primary purpose of this presentation is to review the development of EMG biofeedback in rehabilitation from both historical and clinical perspectives so that the practitioner can better appreciate the observations just noted. Secondary purposes underlying the relevance of this article are to describe other forms of feedback (force and positional) presently employed in the rehabilitative process and to address future needs and directions to more appropriately comprehend the importance of these electronic devices.

HISTORICAL PERSPECTIVE

The predecessor of what is today known as muscle biofeedback was first described by Marinacci and Horande (1960). These clinicians used an electromyogram to provide "feedback" of raw muscle