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Surface EMG Biofeedback in Neuromotor Rehabilitation

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SURFACE-EMG-BIOFEEDBACK IN NEUROMOTOR REHABILITATION

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INTRODUCTION

Although there is evidence that sEMG-guided motor rehabilitation is beneficial for example in post-stroke rehabilitation [4], or in cerebral palsy [5], surface-EMG-Biofeedback (sEMG-BFB) has not yet been sufficiently incorporated into routine neuromotor rehabilitation concepts especially in Europe.

METHODS

Review. sEMG-BFB treatment strategies are discussed in the light of motor-learning concepts.

DISCUSSION

sEMG-Feedback is effective in producing relaxation, active muscle control, and awareness, but the acquisition mechanisms are not clear. Investigation of short-term performance during and after feedback training may not relate to long-term learning [2].

Voluntary movements are goal directed and improve with practice as a result of feedback and feed-forward mechanisms: Motor programs are continuously refined by learning. There are changes and shifts of anatomical location of representations of motor programs as motor behavior progresses, through learning, from being novel to being automatic [3]. Early mapping experiments stimulating the cortical surface electrically initially led to the simplistic idea that the primary motor cortex […] controls individual muscles or small groups of adjacent muscles. More detailed studies […] demonstrate that neurons in several cortical sites project axons to the same target. In addition, most stimuli activate several muscles, with muscles rarely being activated individually […] An implication of this redundancy in muscle representation is that inputs to motor cortex from other cortical areas can combine proximal and distal muscles in different ways in different tasks [3].

The somatotopic organization of the motor cortex is plastic. It can be altered during motor learning and following injury. The idea that the organization of at least some mature motor circuits can change depending on sensory or motor activity holds important promise for the rehabilitation of patients [3].

Motor processing begins with an internal representation, namely the desired result of a movement. The brain represents the outcome of motor actions independently of the specific effector: A purposeful movement is represented in the brain in some abstract form rather than a series of joint motions or muscle contractions (motor equivalence) [3].

In providing sEMG-Feedback about the activity of only one or a few muscles a non-physiologic information is given. This seems especially useful in motor-learning contexts with a high fraction of voluntary-online control: New tasks or in exercises with emphasis on precision instead of speed.

Tapering down the extent and promptness of sEMG-Feedbacks in the course of growing skill acquisition seems to be essential for skill retention and transfer. But optimal sEMG-BFB training schedules still have to be evaluated. Practice schedules that promote the rapid acquisition of performance ability are not necessarily those that optimize skill retention and transfer. For example frequent or immediate knowledge of results (KR) or knowledge of performance (KP) may promote a cognitive dependency on the extrinsic feedback, impeding the formation of an intrinsic reference. In the acquisition phase of motor learning a blocked schedule might be preferred, whereas later on, randomized practice might be superior [2].

A thorough evaluation of the patient aims considering activities of daily living warrants motivation. The use of goal directed, functional meaningful and variable tasks is advisable in the light of the motor-learning-concepts presented. A combination of therapeutic functional knowledge and creativity is necessary to figure out an individual training program. The need for combining knowledge about the nature of the neurological lesion, anatomic and kinesiologic facts, strongly limits the applicability of the sEMG-BFB training in a psychological setting.

Kasman et al [2] summarize sEMG-Training techniques: 1. isolation of target muscle activity. 2. relaxation-based down training. 3. threshold-based uptraining/downtraining. 4. tension recognition threshold training. 5. tension discrimination training. 6. deactivation training. 7. generalization to progressively dynamic movement. 8. sEMG-triggered neuromuscular stimulation. 9. left/right equilibrium training. 10. motor copy training. 11. promotion of correct muscle synergies and related coordination pattern. 12. postural training. 13. body mechanics instruction. 14. therapeutic exercises. 15. functional activity performance. Some of the above mentioned training techniques are discussed in detail.

Finally, studies incorporating sEMG-BFB treatment strategies with a sophisticated task oriented approach are presented [6-9]. They serve as an example for future treatment protocols.

CONCLUSION

s-EMG BFB should be integrated more often in neuromotor rehabilitation plans. But considerable efforts are still necessary to standardize the methodology applied (f.e.electrode placement, short- and long-term treatment protocols). There is a need for further clinical studies.

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