Commentary

Comments on "Synergy-Based Functional Electrical Stimulation for Poststroke Rehabilitation of Upper-Limb Motor Functions"

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Abstract

Despite the interesting innovation proposed in the paper, "Synergy-based functional electrical stimulation for poststroke rehabilitation of upper-limb motor functions," concerning the design of functional electrical stimulation (FES) profile, we are skeptical regarding the genuine effectiveness of the applied rehabilitation strategy. In this note, we argue that applying the rehabilitation method proposed in the above-noted work cannot pave the way for eliciting a motor learning process. Consequently, the proposed method cannot be regarded as a FES-based rehabilitation approach for poststroke rehabilitation of upper-limb motor functions.

Keywords: *Functional electrical stimulation, motor learning, stroke*

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Main Concepts and Discussions

Recently, the functional electrical stimulation (FES) has been used for assisting upper motor functions after stroke.[1] The utilized FES device was a multichannel computer-based FES system.[1] The width of pulse and frequency of the stimulating waveforms were 200 µs and 50 Hz, respectively.[1] In the mentioned work, it was focused on generating FES patterns based on muscle synergy patterns extracted ffrom healthy subject. The experiments were conducted on ischemic poststroke patients afflicted between 2 and 10 months before participating in the study.[1] The location of infarction in the patients was different.[1] The two sets of experiments were carried out using a programmable multichannel FES device. In one of the conducted experiments, the FES was applied to three patients during performing some task-oriented training.[1] Two reaching tasks including forward reaching and lateral reaching were performed.[1] The outcome of the applied short-term intervention was measured by Fugl–Meyer scores and movement kinematic analysis.[1] The performed assessments indicated improvement in both Fugl–Meyer scores and movement kinematics. In addition, the elicited muscle synergy of the patients evolved toward the normal one.[1] Although the reported results are promising and can show the therapeutic effect of applying FES, considering such approaches as a genuine rehabilitation method is in question. To prove this comment, the above work will be addressed in terms of three main aspects in the following subsections.

Genuine Meaning of Motor Rehabilitation

It is believed that motor rehabilitation is fundamentally a process of movement relearning.[2] Accordingly, assisting a poststroke patient to perform the same movement independently using movement alternatives cannot necessarily give rise to eliciting the motor learning process. For example, the importance of the concept of the internal model to the rehabilitation of arm movement has been discussed in some of the literatures.[3] Furthermore, it has been emphasized that the formation of appropriate internal models is the main prerequisite for rehabilitation.[4] Thus, the repetition of arm movements using technologies such as FES or robotic devices cannot guarantee the formation of internal models because the movement training process includes no cognitive subprocess

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and cannot yield motor learning. Therefore, it cannot be regarded as a rehabilitation method for arm movement in stroke patients. Furthermore, observing some therapeutic improvements merely cannot reflect motor learning. In other words, some temporary changes in performance might be misleading.[5]

Eliciting motor learning in neurorehabilitation implies active patient involvement[6] as well as performing random tasks.[7] The reason why active patient involvement might trigger learning is that the context-specific motor tasks and related feedbacks promote learning motor strategies.[8,9] Moreover, performing a random task might contribute to motor learning because it promotes considering each movement as a problem-solving process.[7] In the mentioned work,[5] the participants performed two simple repetitive tasks without incorporating a human–device interactive process. Accordingly, the reported therapeutic improvement cannot be regarded as the result of a motor relearning process. Consequently, it cannot be taken into account as a genuine motor rehabilitation.

Muscle Synergy and Motor Learning

According to a renowned theory, after performing a learning process and optimizing the motor tasks such as reaching and grasping, such skills may be represented in the central nervous system as motor synergies.[10] It means that the motor synergies are optimized through learning mechanisms (implicit and explicit learning).[10] Accordingly, optimizing the motor synergies can be a reasonable goal of a rehabilitation method. However, imposing a repetitive movement designed according to a synergy pattern, as applied in the addressed work,[1] cannot guarantee the optimization of the muscle synergies because the movement training process includes no cognitive subprocess and cannot yield motor learning. There is a subtle difference between motor skill learning through synergy-based mechanisms, as applied in some works,[10] and the method applied in the addressed work.[1] While motor skill learning through synergy-based mechanisms can elicit implicit learning, imposing a movement cannot elicit such a learning process because although it has been designed according to a synergy pattern, it does not contain a cognitive subprocess. Thus, the reported improvements utilizing the FES in the addressed work[1] might be more commonly attributed to an emerging muscular compensatory mechanism rather than a true motor learning.

Permanent Changes in Behavior

The motor learning reflects some concepts. Producing relatively permanent changes in behavior is one of the main related concepts.[11] Thus, examining the persistence of the observed changes for a significant period after training is critical.[12] This can be examined reasonably through a follow-up analysis. This would make it possible for a test taker to look at the test results over a long period. In the addressed work,[1] all clinical and kinematic analyses were carried out once before and once after the 5-day intervention. Merely observing some changes after the only 5-day intervention, without follow-up analysis, cannot assure the clinicians to assign the applied intervention as a rehabilitation method.

Conclusion

Overall, the authors believe that the FES-based therapeutic approach, which was proposed and applied in the addressed work,[1] cannot be a genuine rehabilitation approach for poststroke patients. Instead, the aforementioned work can be only a prelude to the design of the innovative rehabilitation techniques for poststroke patients using FES.

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Conflicts of interest

There are no conflicts of interest.

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