PRIMING THE MOTOR SYSTEM
PASSIVE AND ACTIVE MOVEMENTS INDUCE DISTINCT GABAergic EFFECTS

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INTRODUCTION

Following stroke, the brain undergoes plastic changes including: diminished neural connectivity within the ipsilesional hemisphere contributing to imbalanced inter-hemispheric inhibition and over-excitability of the contralesional hemisphere. Therapeutic interventions that reduce inter-hemispheric competition may improve motor function and contribute to rehabilitative treatments [3]. Priming by a method known as Active-Passive Bilateral Activity (APBA) can improve the overall balance of inter-hemisperic inhibition, increasing TCI from AH-to-UH as well as intracortical inhibition (SICI) in the UH [1].

Here we use the Davey technique [2] to investigate activity in cortical inhibitory circuits following passive and voluntary motor activity. According to [2], EMG suppression in response to sub-threshold TMS corresponds to activation of cortical inhibitory interneurons mediated by GABA involved in motor activity.

METHODS

In this UF IRB-01 approved study we used sub-threshold transcranial magnetic stimulation (TMS) [2] to elicit EMG suppression and investigate the effects of passive and resisted movements on corticomotor drive. Four healthy females, aged 18 to 22 years, participated. Sub-threshold TMS (~0.7x MT) was delivered to the contralateral hemisphere during sustained isometric contraction of the first dorsal interosseus (FDI): at rest, following passive, and following active-resisted wrist flexion/extension movements. To determine the persistence of exercise effects on the cortical circuitry, two participants were re-tested following a 10-15 minute rest period.

RESULTS AND DISCUSSION

Our data reveal that both passive and active exercises modulate neural inhibition and in many cases produced a marked facilitation. Following passive movement, the magnitude and duration of EMG suppression was markedly increased. Following active-resisted movement, increased EMG suppression was followed by facilitation. This facilitation may be a key phenomenon to improving the efficacy of neurorehabilitation interventions.

Figure 1: Dotted line corresponds with MEP latency. Subject 33 reveals EMG suppression in the baseline condition (purple line). Following PASSIVE movements (green line), EMG suppression is deeper and followed by a notable facilitation observed at ~50 ms (black cursor). These effects are augmented following ACTIVE, resisted exercise (blue line).
While it is expected that the facilitation induced by active and passive movements diminishes with time, our data in two participants suggest the facilitation persisted 10-15 minutes post-exercise. We intend to conduct more experiments to fully understand the time course of this phenomenon.

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Figures 2: Subject 40 was re-tested 10-15 minutes following post-exercise. Persistent post-exercise facilitation is observed.

There is great interest in identifying adjuvant treatments to partner with traditional rehabilitation. Candidates argued to produce priming effects include: pharmacologic agents (e.g., amphetamine, L-dopa, D-cycloserine), repetitive TMS (rTMS), mental practice, and passive movement (in the form of APBA). It is recognized that exercise produces significant neuromodulatory effects without significant negative side effects. However, the specific mechanisms have not been fully explored.

These data illustrate neural mechanisms involved in activities used for priming and suggest that priming prior to traditional rehabilitation treatment could enhance neural excitation and therefore increase the effectiveness of treatment. Before this method can be applied in stroke rehabilitation more research needs to be done on healthy individuals to determine the magnitude, consistency and persistence of these effects. Further, effects will likely differ in persons post-stroke because the functioning of inhibitory cortical circuits is impaired. Our ongoing work seeks to develop our understanding of this phenomenon.

CONCLUSIONS

EMG suppression, as first described by [2], reflects activation of GABA-mediated cortico-cortico inhibitory interneurons. Because these interneurons are activated by cortical neurons, EMG suppression is used to confirm cortical involvement in the motor task (e.g., corticomotor drive). Consistent with the motor priming hypothesis proposed by [1] enhanced EMG suppression observed following passive movement is consistent with enhanced corticomotor drive. Our data suggest a neural mechanism by movement-related activation and feedback influence the cortical circuitry. These effects will likely differ in persons post-stroke because cortical circuits are impaired. Regardless, both passive and active-resisted movements offer a non-invasive approach to increase cortical excitability, induce ‘priming’ and potentially enhance treatment efficacy.

REFERENCES


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