1997

Antagonist Muscle Inhibition During Voluntary And Automatic Movements: Implications For Clinical Intervention

Charles Leonard

Charles Leonard
University of Montana - Missoula, charles.leonard@umontana.edu

T. Matsumoto

P. M. Diedrich

J. A. McMillan

Extended Abstracts Platform Presentations CSM '97, Dallas, Texas

Does Exertion Exacerbate Motor Dysfunction In Persons With Post-stroke Hemiplegia?

Brown DA, Kautz SA, and Dairaghi CA, Rehabilitation R&D Center, VA Palo Alto Health Care System, Palo Alto, CA.

This work was supported, in part, by The Foundation for Physical Therapy and The Department of Veterans Affairs, Division of Rehabilitation Research and Development.

Undue exertion has been discouraged in persons with post-stroke hemiplegia because it is thought to exacerbate abnormal postures and dysfunctional movement patterns. To determine if motor performance does, indeed, worsen with exertion, we quantified mechanical and electromyographic (EMG) measures of motor performance during a well-controlled locomotor task (pedaling an ergometer) performed over a wide range of workload and speed levels.

Fifteen subjects with chronic (>6 months since onset) post-stroke hemiplegia and 12 age-matched control subjects participated in this study. Subjects were asked to pedal a bicycle ergometer at 3 constant cadence (25, 40, and 55 rpm) and at 4 constant workload (45, 90, 135, and 180 Joules) combinations presented in random order. Mechanical measures of impaired performance included mechanical work done and total negative work done by the plegic leg. EMG measures of impaired performance included quantification of inappropriate muscle activity. Repeated measures two-way ANOVAs were used to compare changes in mechanical and EMG measures under the different workload/speed combinations.

Results showed that mechanical work done by the plegic leg was more negative (20% vs. 45% of total work for plegic vs. control) and total negative work was greater (-31% vs. -10% of total work for plegic vs. control) than control subject values. At least four patterns of dysfunctional muscle activity were observed, namely 1) prolonged soleus activity, 2) early medial gastrocnemius activity, 3) prolonged vastus medialis activity, and 4) early rectus femoris activity. Contrary to conventional expectations, these dysfunctional measures did not change with increased exertion. Mechanical work by the plegic leg increased ($p<.0001$) without increased total negative work, and inappropriate patterns of activity remained unchanged as overall activity increased ($p<.0001$) with exertion.

We conclude that, given an already present movement dysfunction, increased exertion due to speed and workload does not further impair functional output and muscle activity during pedaling in persons with spastic hemiplegia. This work demonstrates that, while undue exertion results in increased activity in muscles that are inappropriately activated, exertional exercise may provide advantageous training benefits without further generating disordered control.

However, there are a few caveats worth mentioning. First, high levels of exertion should be approached with caution in patients with history of cardiac or orthopedic pathologies. Second, we did observe various degrees of abnormal postures and associated movements that appeared to be brought on at high levels of exertion. However, our results showed that they did not interfere with the subject's ability to increase force output. If we as physical therapists, are interested in designing exercise programs that target increased muscle force output during movements, then we recommend exercises that allow movements against heavy loads and at higher speeds.

Antagonist Muscle Inhibition During Voluntary And Automatic Movements: Implications For Clinical Intervention.

Leonard CT*, Matsumoto T**, Diedrich PM*, McMillan JA***. *University of Montana, Missoula, MT. ** Kyoto University, Kyoto, Japan. ***Montana State University, Bozeman, MT.

Various rehabilitation techniques encourage eliciting automatic reactions in the hope that muscle activiations elicited in this way will influence voluntary movement. Unlike voluntary movements that consist of willed initiation and involvement of descending corticofugal and and basal ganglia pathways, automatic postural reactions resulting from external perturbations primarily involve peripheral receptors arising from the vestibular apparatus, muscles, joints, and eyes. We were interested to determine whether voluntary and automatic movements, which are initiated very differently, involved similar temporal activation of muscles and the same pattern of reciprocal inhibition between agonist and antagonist motor neuron pools.

Changes in soleus muscle alpha motor neuron excitability, assessed by H-reflex testing, were examined in standing subjects during voluntary contraction of the tibilais anterior (TA) muscle and during a poterior-to-anterior displacement of a balance-platform. The platorm induced perturbation elicited a TA contraction that was similar to that of a voluntary contraction. A repetitive H-reflex methodology was used to test eight subjects (x age= 30.4 ± 8.9 years; range=21 to 45 years; 5 females, 3 males). H-reflex recordings were obtained prior to, during, and following either verbal commands to dorsiflex (voluntary condition) or following a posterior to anterior horizontal balance platform translation (automatic reaction). H-reflexes were normalized to each individual's maximum M wave (MaxM). Changes in soleus H-reflex amplitudes were analyzed in relation to onset of TA muscle EMG activity.

Voluntary movements and automatic reactions resulted in similar decreases in soleus H-reflex amplitudes immediately fol-

lowing TA contraction [inhibition following voluntary movement=from 9.08% ± 4.04 to 3.71% ± 2.15 MaxM (p=.005)]; inhibition following automatic reactions = 8.7% ± 1.2 to 3.43% ± 3.06 MaxM (p=.005)]. During voluntary movement significant decreases in soleus H-reflexes (9.08% ± 4.04 to 6.9% ± 3.67 MaxM; p=.025) preceded TA contraction by 0 to 50 ms. In contrast to voluntary ankle dorsiflexion, decreases in soleus H-reflexes did not precede TA activation during automatic reactions 8.7% ± 1.2 to 8.31 ± 4.5 MaxM; p=.25).

These results indicate that temporal coordination and reciprocal inhibition between ankle flexors and extensors is not similar for voluntary and automatic movements. The inhibition of an antagonist muscle prior to agonist activation during voluntary movement has been attributed to supraspinal influences that include corticofugal pathways.[1] During automatic reactions, the inhibition of the antagonist muscle does not occur prior to agonist contraction. It appears that antagonist inhibition is more dependent on peripheral receptor activity most likely arising from the contracting agonist muscle.

These data suggest that since voluntary movement and automatic reactions are dissimilar in their temporal organization and very likely involve different neural control properties, that the use of automatic reactions to enhance the motor control of voluntary movements would not be advantageous. This does not necessarily indicate that eliciting automatic reactions is an inappropriate therapeutic tool. For some neurological patients, muscle paresis contributes to their disability. Many patients who cannot voluntarily generate muscle activity, do domonstrate increased muscle activation during postural perturbations. Since repetitive stimulation of a neural pathway enhances transmission along the pathway,[2] it is possible to theorize that repetitive muscle contractions elicited by automatic reactions might result in an alpha motor neuron requiring less descending or afferent input to reach synaptic threshold. This remains theoretical and has yet, to our knowledge, been tested directly.

References

1 Rothwell JC, Day BL, Berardelli A, and Marsden CD. Effects of motor corex stimulation on spinal interneurones in intact man. *Exp. Brain Res.* 1984;54:382-384.

2 Kandel ER, and O'Dell TJ. Are adult learning mechanisms also used for development? *Science*. 1992;258:243-245.

Actions Speak Louder Than Words: A Case Study Demonstrating Declarative But Not Procedural Memory Deficits.

Sullivan KJ, Winstein CJ. Department of Biokinesilogy and Physical Therapy, University of Southern California, Los Angeles, CA (Extended abstract).

Historically, the early investigations of H.M. (Corkin, 1968), an individual with bilateral medial-temporal lobe resection, provided some of the first evidence that two dissociable forms of memory-learning capability are supported by functionally distinct neural substrates within the brain. Declarative memory is conscious explicit memory, indicated by the recall of facts and events. Procedural memory is unconscious implicit memory, indicated by observing changes in performance as a result of experience. A common clinical tenet is that individuals with brain injury who have severe cognitive impairments such as memory loss are not capable of benefitting from therapeutic interventions that require the individual to recall information from one treatment session to another. However, seldom do we as physical therapists separate the recall of factual information from the capability to recall actions. The purpose of this case study was to examine the effects of practice on the motor learning of a rapid arm movement in an individual with severe declarative memory deficits.

A 78 year old female (RM) diagnosed with Alzheimer's Disease (AD) participated in this study. The motor task was to produce a specific goal-movement consisting of three elbow flexion-extension reversals with a 1000 ms movement time (MT) goal. The subject practiced the task for 200 trials on Day 1 and returned Day 2 for two retention tests. Dependent measures included: 1) root mean square error (RMSE) and 2) MT. Across practice, RM demonstrated improvements in movement accuracy (RMSE) and speed (49%). A questionnaire about the previous day's activities was administered on Day 2. RM had no recall of the examiner's name, the testing location, or the practiced task (when cued she responded by saying she had been moving her neck). Despite having no declarative recall of the practiced task, RM demonstrated spared motor learning indicated by performance on the retention tests. RMSE during Day 2 no-feedback retention was similar to that at the end of Day 1. Reacquisition performance, when FB was reintroduced, surpassed Day 1's performance. Particularly striking was the retention of MT.

The preservation of motor learning capability in the presence of declarative memory deficits demonstrated in this case study has been reported previously in AD,[1] Korsakoff's syndrome,[2] and post-traumatic amnesia.[3] Physical rehabilitation of individuals with brain injury who present with cognitive deficits such as severe declarative memory impairments may benefit from rehabilitation strategies that focus on direct acquisition of skills such as task-specific training where progress is documented as changes in performance (eg, faster performance, less error). Often our physical assessments are focused at the level of physical assistance required to complete a mobility task. Timed assessments may be a better indicator of improvements in skill acquisition particularly in our brain injured clients who present with severe cognitive deficits but from a physical standpoint are relatively independent in activities of daily living.

References

1 Deweer B, Ergis AM, Fossati P, Pillon B, Boller F, Agrid Y, Dubois B. Explicit memory, procedural learning and lexical priming in Alzheimer's disease. *Cortex*. 1994;30:113-126.

2 Nissen MJ, Bullemer P. Attentional requirements of learning: evidence from performance measures. *Cognitive Psychology*. 1987;19:1-32.

3 Ewert J, Levin HS, Watson MG, Kalisky Z. Procedural memory during post-traumatic amnesia in survivors of closed head injury. *Archives of Neurology*. 1989;46:911-916.