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TRANSLATIONAL PERSPECTIVES

Nothing either good or bad but action makes it so

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Federico and Perez, in a recent issue of *The Journal of Physiology*, provide new insight into the impact of incomplete spinal cord injury (SCI) on corticospinal preparation for movement (Federico & Perez, 2017). In people with chronic incomplete cervical SCI and age-matched control subjects, they measured motor evoked potentials evoked by cortical (MEPs) or subcortical (CMEPs) stimulation and short-interval intracortical inhibition (SICI) in the first dorsal interosseous muscle during preparation for a reaction-time task in which the person was instructed to make (GO) or not make (NOGO) a ballistic index finger isometric contraction. In the control group, both the cortex and the spinal cord were excited over baseline in the preparatory phase of GO trials and inhibited in NOGO trials. In contrast, in the group with SCI, only the cortex was excited in GO trials, while neither cortex nor spinal cord was inhibited in NOGO trials.

These group differences answer the question the study asked; they indicate that incomplete SCI affects movement preparation on both cortical and spinal levels. At the same time, as good experiments often do, the study also raises a new and important question. Notably, the differences found between people with or without SCI were group differences; they were not evident in every person. For example, a few control subjects did not show reduced MEPs and/or increased SICI in NOGO trials, and a few subjects with SCI did do so. The differences found among the control subjects indicate that different normal individuals prepare for movement (or non-movement) in different ways; yet they all perform satisfactorily. This raises the new question: do the group differences reported in the paper represent impairments produced by SCI or adaptations that compensate for other impairments? Stated most simply, are the differences good or bad?

It seems most probable that the group differences reflect both impairments and adaptations. The lack of task-related modulation (i.e. facilitation or suppression) of CMEPs in the preparatory period in the group with SCI could indicate deficient supraspinal control of spinal cord excitability, while the loss of intracortical inhibition might reflect adaptation that maximizes the cortex's remaining ability to activate the target muscle. In this regard, it is interesting to note that the control group and the group with SCI showed similar MEP increases for GO trials, while only the control group showed a CMEP increase. Thus, the MEP increase in the control group reflected both cortical and spinal excitation, while the equally large MEP increase in the group with SCI reflected only cortical excitation. This implies that the MEP increase in the group with SCI was due to cortical excitation that was greater than the cortical excitation in the control group, and thereby made up for the loss of spinal excitation. This too may reflect adaptation.

Furthermore, just as the differences found among the control subjects may reflect differences in their past histories of motor training, the differences between the control group and the group with SCI may reflect the impact of rehabilitation regimens on the latter. Standard regimens focus on restoring the ability to move (e.g. GO trials), rather than the ability to suppress movement (e.g. NOGO trials). This emphasis may contribute to the fact that the task-related MEP, CMEP and SICI differences between the control group and the group with SCI were most marked for the NOGO trials.

Ultimately, a specific physiological effect of SCI, such as reduced cortical inhibition, is beneficial or detrimental only in terms of its impact on a specific action, such as, in the present study, rapid index finger abduction. By the same token, a specific effect may be beneficial for one action and detrimental or unimportant for another; whether it occurs in a specific person after SCI may depend in part on the balance reached among the adaptive processes (i.e. the activity-dependent plasticity) driven by different actions (Wolpaw & Tennissen, 2001; Adkins *et al.* 2006; Zehr, 2006; Wolpaw *et al.* 2010).

Whether a specific SCI-associated physiological abnormality is beneficial or detrimental is not simply a theoretical issue; it is now acquiring practical clinical importance. New technology-based interventions make it possible to target activity-dependent plasticity to the neural circuitry underlying specific physiological measures (e.g. H-reflexes, MEPs; Taylor & Martin, 2009; Thompson *et al.* 2009; Bunday & Perez 2012; Edwardson *et al.* 2014). Thus, it is possible to strengthen or weaken defined components of the neural networks responsible for important actions such as locomotion. Furthermore, appropriately targeted plasticity can trigger wider beneficial plasticity and thereby substantially improve actions impaired by injury or disease (e.g. Thompson *et al.* 2013). Sometimes the choice of intervention (i.e. which measure to target and whether to increase it or decrease it) is clear (e.g. Thompson *et al.* 2013); other times, the choice may be difficult. Guidance might be obtained from intra- and/or inter-subject correlations between a given measure and performance of one or more important actions, and from correlations between changes in the measure and the performance improvements produced by standard therapeutic regimens. With such guidance, these new targeted interventions could be designed to address each individual's particular deficits; combined with other therapies, they may enhance recovery of useful function in people with SCI, stroke, or other neuromuscular disorders.

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Additional information

Competing interests

None declared.