CROSSED REFLEX REVERSAL DURING HUMAN LOCOMOTION: EVIDENCE FOR FUNCTIONAL SIGNIFICANCE

SABATA GERVASIO

Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Fredrik Bajers Vej 7 D-3, Aalborg - DK 9220, Denmark.

When we walk, a fine coordination between the two legs is required, in particular when an unexpected change in the over ground surface or the encountering of an obstacle threaten our balance. Even if the topology of the networks involved in this coordination is not yet completely known, a coupling of the neuronal circuits controlling each leg have been suggested basing on studies involving locomotion on a split belt treadmill (Reisman et al., 2005, 2007).

In animals, direct commissural interneurons connecting opposing limbs have been identified within the spinal cord (Jankowska & Noga, 1990; Edgley *et al.*, 2003; Jankowska, 2008). Recently our group provided evidence suggesting that similar interneurons may exist in healthy humans. Indeed, a short-latency inhibition of the contralateral soleus muscle (cSOL) followed by a short-latency facilitation in the contralateral gastrocnemius lateralis (cGL) have been quantified following ipsilateral tibial nerve stimulation (iTN) (Stubbs and Mrachacz-Kersting, 2009; Stubbs et al., 2011a, 2011b, Gervasioet al. unpublished data). A functional significance of these connections has been proposed since the response showed a phase dependent modulation during locomotion, with the most prominent responses occurring before and during the swing to stance transition of the stimulated leg (Stubbs *et al.*, 2011*b*). When a sudden event perturbs the ipsilateral leg at this time, an inhibition in the cSOL could, indeed, prevent the push off of the contralateral foot and the progress of the perturbed step while a complementary facilitation in the gastrocnemii would enhance the degree of mechanical coupling between ankle and knee and ensure the stability of the limb (Duysens et al., 2001).

One more argument sustaining the functionality of these connections is the evidence that when an opposite reaction is required, a reversal of these responses can occur and is particularly evident in the cGL. Crossed responses in the SOL and GL have been investigated at 40-50% of the gait cycle during hybrid walking when the ipsilateral leg in push off and contralateral leg in touch down create a condition of increased instability that requires appropriate interlimb coordination in order to react rapidly to a disturbance of balance (Gervasio et al. unpublished data). iTN stimulation in this condition, elicits a crossed inhibition in the cGL and, in some subjects, a crossed facilitation in the cSOL, that could have the function of preventing

the knee flexion from contaminating the induced reduction in ankle dorsiflexion in the contralateral leg (Duysens et al., 1991).

The existence of direct spinal connections mediating crossed reflexes during locomotion represent itself a promising finding for the development of new rehabilitation approaches for patients presenting a loss of descending drive such as stroke or spinal cord injuries patients. The perspective of the functionality of these connections would allow a further step through the prospect of conditioning these pathways in order to promote the recovery of symmetry and functionality during locomotion in this patient population. Nevertheless, without any kinematic and kinetic measurement, the functionality of these pathways can only be speculated.

With this attempt, kinematic data furnished by a motion capture system will be recorded bilaterally together with load data recorded by an in-shoe foot pressure measurement system. The behavior of the body Center of Mass (CoM) and Center of Pressure (CoP) will be investigated during normal and hybrid walking tasks and gait index such as "symmetry" will be extracted. Moreover the effect of crossed responses on these parameters will be evaluated.

The results provided by this protocol will allow confirming the hypothesized functional significance of spinal crossed responses and lead to the prospect of conditioning these pathways as a new rehabilitation approach.

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