Motor abundance, compensation and adaptability in the stroke-damaged nervous system.

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Background

In motor tasks such as reaching from sitting or standing, the nervous system has to organize the action of a large number of body segments and joints in order to maintain reaching accuracy. Reaching can be accomplished by different combinations of joint movements permitting the system to adapt to unexpected situations, a process known as motor equivalence. Following a stroke or damage to the central nervous system, deficits in motor planning and execution may ensue, leading to a reduced capacity to use the affected upper limb to meaningfully interact with objects in the environment. The capacity for adaptability depends on the residual ability of the nervous system to use its kinematic redundancy to find solutions to motor problems. Reductions in redundancy may be related to deficits in threshold control and the specification of referent body postures.

Methods & Results

Results of studies investigating how the stroke-damaged nervous system organizes reaching movements based on limited redundancy will be presented, while considering the extent to which compensatory motor patterns are adaptive. For example, people with stroke use excessive arm-plane motion to compensate for limited shoulder flexion, however, those with more severe stroke were unable to adapt such movements to improve reaching accuracy. Further investigation of adaptability will be illustrated with results of studies of kinematic adaptability to sudden perturbation of the trunk when reaching from sitting and when reaching from standing. These studies show that people with even mild stroke have difficulty in rapidly changing elbow-shoulder interjoint coordination patterns to adapt reaching movements to sudden perturbation and that this difficulty may be related to a limited ability to regulate the tonic stretch reflex threshold of muscle groups recruited for the motor action.

Conclusion

The ability to appropriately adapt interjoint coordination to changing task conditions is impaired in individuals with stroke, which may be explained by impairments in threshold control leading to deficits in the specification of referent body configurations for control of reaching.

Significance

Deficits in higher order motor control skills related to the use of motor compensations to adapt to unexpected situations, may restrict motor recovery. This capacity is not routinely identified in commonly used clinical scales.

Dr. Levin trained as a physiotherapist at McGill University and practiced for several years at the Rehabilitation Institute of Montreal where she specialized in neurological rehabilitation. She then obtained a M.Sc. degree in Clinical Sciences from the University of Montreal followed by a Ph.D. in Physiology from McGill University under the directorship of Dr. Christina Hui-Chan. She completed an additional two years of post-doctoral training in neurophysiology at the University of Montreal under the co-directorship of Drs. Yves Lamarre and Anatol G. Feldman. From 1992 to 2004, Dr. Levin held positions as researcher and professor in the School of Rehabilitation at the Université de Montréal. She taught courses at the undergraduate and graduate level mainly in the areas of electrotherapy and neurology. Dr. Levin was Scientific Director of the Research Centre of the Rehabilitation Institute of Montreal from 1997 until November 2001. She was a Research Scholar of the Fonds de la Recherche en Santé du Québec from 1992 until 2004. In 2004, Dr. Levin became the Director of the Physical Therapy Program in the School of Physical and Occupational Therapy at McGill University until 2008 and was awarded a Tier 1 Canada Research Chair in Motor Recovery and Rehabilitation (2005-2012, 2012-2019).

Dr. Levin served as President of the International Society of Motor Control from 2005 to 2008 and is currently editor of the Society's journal "Motor Control". She was a founding member and is immediate Past-President of the International Society for Virtual Rehabilitation as well as a founding member and current executive member of the International Neurological Physiotherapy Association of the World Physical Therapy Association.

Dr Levin's research focuses on elucidating the mechanisms underlying arm sensorimotor deficits and their recovery in adults and children with central nervous system lesions. Her research program aims to elaborate the pathophysiological mechanisms underlying disordered motor control and learning after brain damage and then to develop and test treatment interventions to remediate sensorimotor impairments and disabilities based on these findings. Amongst her research methodologies are new technologies such as virtual reality and robotics.