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CASE REPORT

Application of neuroplasticity theory through the use of the *Feldenkrais Method*® with a runner with scoliosis and hip and lumbar pain: A case report

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Abstract Neuroplasticity theory has gained considerable attention in recent years in the professions of medicine, psychology and neuroscience. Most research on neuroplasticity has been in neurology focusing on stroke and other central nervous system disease and injury. Further research is necessary to advance the connection of neuroplasticity theory to musculoskeletal conditions and rehabilitation. The theory of neuroplasticity as it applies to the acquisition of new skills and modification of maladaptive, pain-perpetuating and inefficient movement patterns is fundamental to the *Feldenkrais Method*. This case report demonstrates the application of neuroplasticity theory with the *Feldenkrais Method* as the primary intervention for a 42-year-old female runner with a history of adolescent idiopathic scoliosis who presented with hip and lumbar pain. The client had clinically meaningful improvements in pain intensity and the Global Rating of Change scale while meeting her goals to resume pain free running, repetitive stair climbing at work, and other leisure activities.

Background and purpose

Neuroplasticity theory has gained considerable attention in recent years in the professions of medicine, rehabilitation, psychology and neuroscience. During the twentieth century, the theoretical assumption was that our brain anatomy, function and habits were hard-wired and fixed, and as we aged, the brain lost neurons and therefore an inability to change and learn new skills (Bruel-Jungerman et al., 2007; Doidge, 2007; Flor, 2003; Zemach-Bersin, 2010). Evidence is growing to support the concept that the central nervous system (CNS) encodes new experiences

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and has the ability to change quickly, learn new behaviors and skills, and recover lost functions (Zemach-Bersin, 2010; Flor, 2003; Kleim and Jones, 2008; Boudreau et al., 2010). Most of the research on neuroplasticity has been in the area of neurology focusing on stroke and other CNS disease and injury, while recently evidence is emerging relating it to musculoskeletal conditions (Boudreau et al., 2010; Snodgrass et al., 2014).

Neuroplasticity occurs dynamically throughout the life span with the ability of the nervous system to adapt to stimuli through regeneration and reorganization of its neuronal structure, function and connections. Neuroplasticity can be either adaptive or maladaptive where plasticity risks can result in pathology, dysfunction and chronic pain (Cramer et al., 2011; Snodgrass et al., 2014; Flor, 2003; Boudreau et al., 2010; Pascual-Leone et al., 2005). Maladaptive responses such as learned non-use or disuse, compensatory movements, alterations in movement patterns, and feedback and feedforward mechanisms can be reversed through motor skill training (Kleim and Jones, 2008; Boudreau et al., 2010; Snodgrass et al., 2014; Pascual-Leone et al., 2005; Young and Tolentino, 2011; van Vliet and Heneghan, 2006; Tsao and Hodges, 2008). Task specific training with a whole functional movement, rather than a focus on specific body parts or joints, has been shown to be more effective with neurological conditions. Variety with direction, speed, and positions enhances the transfer of the training to real life (van Vliet and Heneghan, 2006).

Most physical therapists do not consider neuroplasticity of the CNS in their approach to rehabilitation of musculoskeletal conditions, and instead evaluate and treat regional specific movement dysfunction, in contrast to their colleagues who work with neurological dysfunction. As neurological and musculoskeletal disciplines share information towards creation of collaborative models, application of the motor learning principles that bring about cortical neuroplastic reorganization will offer potential for more rehabilitation success for the clients with musculoskeletal impairments (Boudreau et al., 2010; Snodgrass et al., 2014).

The theory of neuroplasticity for learning new skills and modifying maladaptive, pain perpetuating and inefficient habits is fundamental to the *Feldenkrais Method*. Although the *Feldenkrais Method* is one of the lesser known and researched approaches, it has been used by physical therapists and other professionals trained in the method for the recovery of clients suffering from musculoskeletal conditions (Hillier and Worley, 2015).

Integral to the *Feldenkrais Method* is the application of the laws of physics and motion, the learning process, and the manner in which actions are discovered, similar to how children solve the challenges of the physical world to discover new movement (Zemach-Bersin, 2010; Ginsburg, 2010). *Feldenkrais* uses a model of learning showing the interrelatedness of the skeleton, muscles, CNS and environment in a non-causal circular relationship (Ginsburg, 2010) (Fig. 1). Application of the principles of the Weber—Fechner Law, whereby reducing the background noise of muscular effort and pain with slow small movements, improves kinesthetic and sensory acuity. Finer distinctions can then be made to facilitate awareness of unconscious physical organization, movement and action. Once a person can sense what they are habitually doing, the opportunity is present for new skill acquisition, changes in "faulty learning" or habits, and recovery of lost skills in spite of profound brain damage (Zemach-Bersin, 2010).

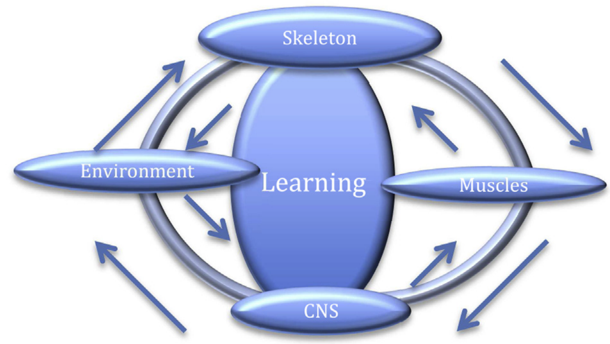

Figure 1 *Feldenkrais* cybernetic loop model of learning, movement and environment.
Adapted from Ginsburg, 2010.

The *Feldenkrais Method* has two modalities derived from the same theoretical basis. *Awareness Through Movement* (*ATM*) lessons, often in a group setting, are verbally guided structured self-explorations of movement designed to bring awareness to sensations accompanying habitual movement patterns from which more efficient and effective functional movement can be learned. Each *ATM* is comprised of approximately 10 variations embedded with learning strategies such as constraints, speed, direction and position to promote discovery of improved functional movement. *Functional Integration* (*FI*) is a hands-on means of gentle tactile, kinesthetic communication to facilitate awareness of habitual behaviors and movement patterns, and foster an expansion of efficient functional movement repertoire. The foundation for *FI* is thousands of *ATM*'s and their variations (Zemach-Bersin, 2010; Buchanan and Ulrich, 2001). Both *FI* and *ATM* have been anecdotally reported to ameliorate the complications related to scoliosis.

Adolescent Idiopathic Scoliosis (AIS) is a three dimensional curvature of the spine that surfaces around puberty, with right-sided thoracic convexities being most common. There are a number of theories, though the etiology remains unclear. Epidemiologic studies show 1—3% of children between the ages of 10—16 will have AIS and most will not require intervention (Weinstein et al., 2008; Parent et al., 2005; Schlösser et al., 2014; Smania et al., 2008). For minor scoliotic curves the ratio with gender is equal, but when the severity of the curve reaches a level requiring treatment, the ratio can rise to 8:1 female to male (Parent et al., 2005). Early detection is important to allow for the opportunity for conservative intervention. Screening is typically performed between the ages of 10—12 with the Adam's forward bend test and a scoliometer (Weinstein et al., 2008; Parent et al., 2005). Trunk rotation $> 7°$ detects nearly all curves $>30°$, but also results in a high number of false positives with many unnecessary radiographs (Parent et al., 2005). Definitive diagnosis is made when a $\geq 10°$ Cobb angle is found on radiographs (Weinstein et al., 2008; Parent et al., 2005). Long-term complications