Australian Spinal Research Foundation

RESEARCH TO REALITY PROJECT

Impact of Somatosensory Input from the Neck on Limb Motoneuronal Excitability and Postural Control Mechanisms

1998 #3: The Impact of Somatosensory Input From the Neck on Limb Motoneuronal Excitability and Postural Control Mechanisms - Polus

HISTORICAL AND PROJECT CONTEXT

In 1998, when this project was funded, we lacked the body of evidence we now have on subclinical neck pain and its impact on proprioception (our sense of where we are in space), spinal reflexes, or the impact chiropractic might have on falls risk, cortical drive or the cortical silent period.

This all had to start somewhere – and Barbara Polus's work on the impact of somatosensory inputs from the neck on limb motoneuronal excitability and postural control mechanisms was one of those seminal pieces.

Polus and her co-investigators set out to investigate whether vibratory stimulation of the dorsal neck muscles activates fusimotor neurons in relaxed subjects. The amount ASRF invested in this project had an impressive impact, with Polus *et al.* producing four publications, five presentations, and three posters. The papers undoubtedly had a far-reaching impact, too, with nods from Melbourne, Australia, where the work originated, to China, the USA and abroad.

Perhaps its greatest contribution was spurring breakthroughs in our current thinking about spinal reflexes, somatosensory input, and the impact of chiropractic care beyond musculoskeletal pain alone.

ABOUT THE STUDY

Polus et al. took fifteen participants and placed them in seated positions. They targeted the triceps surae (TS) muscles (the muscles of the calf) and the subjects were conditioned to leave their muscle spindles in either an insensitive (hold-long) or sensitive (hold -short) state. Researchers then held a vibrator to the dorsal neck muscles for ten seconds. The tendon jerk was evoked from the right TS immediately before or 5 seconds after the vibration was applied.

Researchers were looking at what fusimotor neurons did in this scenario – that is, how did these lower motor neurons, those involved in muscle contraction, behave?

While the initial study reaped results specific to the research question they set out to answer, there were additional findings related to the role of the cervical spine in fall risk in the elderly, a number of findings on unsupported sitting, including the reliability of lumbar paraspinal surface EMG and whole-body rotation with regard to head posture.

Seeing multiple outcomes from a single investment of research funding was a high point in this study, a trend that would later continue in ASRF-funded projects.

The Findings

RESEARCH LEVEL

The study found that the size of the reflex after hold-long muscle conditioning and after neck vibration was significantly smaller than the control short-hold reflex ($P<0.001$). However, after hold-short conditioning, neck vibration significantly increased tendon jerk amplitude, both during ($P = 0.001$) and interposed ($P = 0.026$). This led investigators to the conclusion that dorsal neck vibration increases spinal reflex excitability of the Tricep Surae muscles in relaxed and seated objects but not through fusimotor excitation. That is, it happened at the spinal reflex level, not through lower motor neuron excitability.

Can Neck Muscle Spindle Afferents Activate the Fusimotor Neurons of the Limb in the Relaxed and Seated Human?

- This study provided initial evidence regarding the neck muscle and its relationship to motor neurons in the leg, as well as how spinal reflex excitability might respond to interventions in the neck region.
- Sasaki, H., & Polus, B., (2011) Can neck muscle spindle afferents activate fusimotor neurons of the lower limb? *Muscle and Nerve,* Vol. 45, Iss. 3, 2012, DOI: https://doi.org/10.1002/mus.22300

The Reliability and Validity of Lumbar Paraspinal SEMG During Unsupported Sitting

- Enabled by the same amount of funding, Kamei, Kumar and Polus went on to investigate whether surface electromyography (SEMG) was reliable in a test-retest study with subjects in unsupported seated postures. The SEMG signal was recorded at the lumbar paraspinal level for 60 seconds and then repeated. Twenty participants took part in the study, but post-data-cleaning, it was found that SEMG may not be a reliable and valid method to measure lumbar muscle activity for people in unsupported seated positions. While a negative finding is not always viewed as a successful outcome, in this case, it pointed out the need to find better postures and procedures through which to use SEMG and to measure lumbar paraspinal activity.
- Kamei, K., Kumar, D., Polus, B., (2007) Reliability and Validity or Surface Electromyography (SEMG) to Study the Functional Status of Lumbar Paraspinal Muscles during Execution of the Unsupported Sitting Posture. *Chiropractic Journal of Australia,* Vol. 37. Iss. 1 Pp. 30-37, https://search.informit.org/doi/10.3316/informit.196368179514056

The Role of the Cervical Spine in Balance and Risk of Falling in the Elderly

- This paper reviewed common causes of falls and some possible interventions. A number of validated clinical measures to assess balance and risk of falling were discussed, leading the authors to postulate that the cervical spine may affect balance and risk of falling due to its role in postural control. The role of chiropractic care in preventing falls risk was later expanded on by Dr. Kelly Holt in his PhD thesis and subsequent publications, supported by ASRF funding.
- Walsh, M., Polus, B., and Webb, M., (2004), The Role of the Cervical Spine in Balance and Risk of Falling in the Elderly, *Chiropractic Journal of Australia,* Vol. 34, Iss. 1, pp 19-22 https://search.informit.org/doi/abs/10.3316/informit.617622393719442

The Effect of Longitudinal Whole-Body Rotation Against a Steady Head on Changes in Lower Motoneuronal Excitability – a Study in Humans

- This study examined the influence of the asymmetrical tonic neck reflex induced by longitudinal body rotation against a steady head hold. It essentially measured the tonic neck reflex, which is part of the reflex responses necessary for postural stability. Once again, the study used the Triceps Surae and the H reflex, measures of lower limb motoneuron excitability.
- For each of the eight subjects, the size of the control TS reflex after right body rotation against the steady head was increased. The study demonstrated that the asymmetric tonic neck reflex influences lower limb motoneuron excitability in a reproducible way that may be observed in the awake adult.
- Polus, B. (2001). The Effect of Longitudinal Whole-Body Rotation Against a Steady Head on Changes in Lower Motoneuron Excitability: A study in humans, *Journal of the Neuromusculoskeletal System,* Vol. 9 Iss. 3, pp. 82-87 https://www.researchgate.net/publication/282690203_The_Effect_of_Longitudinal_Whole-Body_Rotation_Against_a_Steady_Head_on_Changes_in_Lower_Motoneuron_Excitability_A_Study_in_Humans

CLINICAL LEVEL

The initial funding amount led to four papers, all examining spinal reflexes and lower limb motoneuronal responses following dorsal neck vibration. Researchers found that dorsal neck vibration increases spinal reflex excitability of the Tricep Surae muscles in relaxed and seated objects but not through fusimotor excitation. This was followed by a paper that examined the TS muscles and the H reflex, showing that the asymmetric tonic neck reflex influences lower limb motoneuron excitability. This opened up the possibility that adjusting the neck might affect lower limb muscles and spinal cord excitability.

Researchers also found that caring for the cervical spine may reduce falls risk in older adults, due to its role in postural control. Overall, the body of work contributed to our understanding of the vital importance of the cervical spine in postural control, and began to unlock our understanding of how this might relate to spinal cord excitability and lower limb motoneurons.

LAYMAN LEVEL

While it is easy to think of neck pain being an isolated phenomenon, research shows that stimulation in the neck may influence muscle spindles and reflexes in the lower limbs. How can this be? The answer lies in spinal cord excitability. That is, when we ensure that the neck is moving well, it can impact lower limb muscle responses, spinal cord excitability, and postural control. This could be because of the way the brain and lower limb muscles communicate with each-other through the spine and nervous system.

As we progress through life, this postural control piece becomes more and more important as falls risk in older adults can be detrimental to health and longevity.