Summary: Noninvasive methods of decreasing hyperreflexia in stroke

Background

Methods of restoring neural function are needed to decrease symptoms of spasticity/hyperreflexia, and ultimately to improve mobility and quality of life whilst decreasing morbidity after stroke. Recently, several non-invasive methods have been shown to decrease reflex excitability in healthy individuals and/or stroke patients, including cutaneous electrical stimulation (Knikou 2013) and tendon vibration (e.g. Pope & DeFreitas, 2015). Moreover, we have shown the potential of water immersion to decrease reflex excitability in stroke patients (Cronin et al. 2016). However, there is a need to compare the efficacy of these methods, as different methods likely affect individuals differently. Since all three of these methods are noninvasive and cheap to administer, their use could form an important part of stroke rehabilitation at the national health level.

In this project, we used a randomised crossover single session design to examine the effects of three cheap, noninvasive methods on reflex excitability in stroke patients and healthy controls. The three methods were: cutaneous electrical stimulation using a ‘sock stimulator’; Achilles tendon vibration; and passive immersion in water. Each exposure was applied to each participant once, for 30 minutes, since this is a realistic timeframe for practical uses of such methods.

Challenges

The contract for this project was extended twice because of unforeseen problems. The first was that the process of getting ethical approval took substantially longer than anticipated. This was due to a number of factors, including the need to translate several documents into Finnish. An additional challenge was related to recruiting enough suitable participants. In fact this process will continue beyond the funded period, but fortunately we made sufficient progress within the project timeframe. Language has presented a further problem, in that two of the primary researchers in the project are non-Finns, although we have since recruited a native Finn with clinical experience, who has helped to solve many of these issues.

Final state of the project

We tested numerous participants from the stroke and control groups, and data collection for the control group was completed towards the end of 2018. Due to variability in the results from stroke patients, we intend to continue data collection in this group, and will recruit these individuals as and when they are available to participate. In any case, as outlined below, the data obtained so far highlight the potential of the methods that were tested. In addition to the originally named research team, we have recently recruited an additional MSc student who has been responsible for data collection and analysis, and has chosen to make this project the focus of his MSc thesis, due to be completed in 2019. We therefore anticipate that the first peer-reviewed publications from this project will appear in late 2019.

Main findings

Effects of passive immersion. The main finding of this part of the study was that maximal H- and M-waves decreased approximately in parallel during immersion, resulting in no change in the Hmax:Mmax ratio. Moreover, changes in H- and M-wave responses occurred in the first 15 minutes of exposure, and the response amplitudes remained at a lower level throughout the remainder of the immersion session. These findings could be due to the effects of both unloading and architectural changes in the neuromuscular system. The early changes seen here suggest that neuromuscular effects of immersion primarily occur within around 15 minutes, and thus shorter bouts of immersion could be beneficial, as well as clinically feasible. Moreover, this method did lead to reductions in reflex excitability, and may thus be useful as part of a stroke rehabilitation programme.

Effects of low intensity cutaneous stimulation. Findings from this part of the study are particularly interesting, because they suggest that in spite of the very low current intensity that was used, there is a clear decrease in spinal excitability after 30 minutes of this protocol. The maximal M-wave amplitude remained approximately constant before and after the protocol, but the maximal H-reflex amplitude clearly decreased after treatment, by up to 25%. This implies a decrease in peripheral excitability. As an additional measure to examine the excitability of the reflex arc, including the muscle spindles, we also evoked tendon tap (stretch) reflexes. As was the case with electrically evoked responses, stretch reflex amplitudes clearly decreased, particularly in the soleus muscle, by around 20% on average. These findings are very promising for expanding the use of this low-cost, noninvasive method, since the method is painless and very easy to administer.

Effects of tendon vibration. After several initial tests we discontinued this phase of the project because the results were very inconsistent. In some individuals, tendon vibration appeared to modify excitability, but clear effects were very difficult to distinguish from measurement error and other sources of noise. Some subjects were also uncomfortable with the device used to vibrate the tendon. Due to these issues, we conclude that this method has limited potential for the treatment of elevated peripheral excitability. This does not necessarily imply that the method is not useful in all cases, but it may require individual-specific testing to identify 'responders' versus 'non-responders' to this treatment. From a practical point of view, however, this is unlikely to be feasible for most healthcare providers, for whom methods with a much higher efficacy are needed.

Conclusions and Recommendations

Both underwater immersion and low intensity cutaneous stimulation of the foot and ankle region show potential to decrease spinal excitability, as measured using electrical and mechanical measures of reflex responses. We will continue to collect data in order to verify these findings in a larger, more diverse sample of people. Importantly, we only tested the effects of a single bout of exposure. In future studies, assuming these conclusions are verified in a larger sample, these noninvasive methods could be used as part of intervention studies to determine their longer term value as rehabilitation tools.

References

Knikou, M. (2013). Neurophysiological characterization of transpinal evoked potentials in human leg muscles. Bioelectromagnetics, 34(8):630-40.

Pope, Z.K. & DeFreitas, J.M. (2015). The effects of acute and prolonged muscle vibration on the function of the muscle spindle's reflex arc. Somatosens Mot Res, 32(4):254-61.

Cronin, N.J., Valtonen, A.M., Waller, B., Pöyhönen, T. & Avela, J. (2016). Effects of short term water immersion on peripheral reflex excitability in hemiplegic and healthy individuals: A preliminary study. J Musculoskelet Neuronal Interact, 16(1):58-62.