ABSTRACT

A NOVEL PEDALING PARADIGM TO IMPROVE LOWER LIMB MOVEMENT POST-STROKE

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Marquette University, 2024

Prior work in our lab revealed that while impaired paretic neuromuscular output contributes to movement difficulties post-stroke, compensation is more related to interlimb coordination (ILC) deficits. Specifically, ILC deficits were revealed in the context of lower limb split-crank pedaling. Participants who demonstrated larger levels of compensation during a conventional, solid-crank pedaling task also demonstrated larger deficits in ILC i.e. maintaining a 180-degree phase relationship during split-crank. To address this deficit, our lab created a novel, split-crank pedaling robot named CUped. CUped (pronounced Cupid) is so called because it compels use of the paretic limb during a movement that resembles pedaling. CUped can create a training environment where ILC can be practiced while emphasizing output of the paretic limb. The purpose of this dissertation was to determine appropriate robotic control schemes and visual feedback methods for CUped.

To achieve this purpose, we evaluated ILC, paretic work output, and velocity pedaling strategy during split-crank pedaling. Aim 1 investigated three proportional control schemes: Assist, Resist, and Assist+Resist. Control schemes provided torque to restore 180-degree phasing proportional to the phasing error. Assist provided forward-direction torque to the lagging limb while resist provided reverse-direction torque to the leading limb. Assist+Resist provided both control actions. Results indicated that Assist+Resist facilitated the lowest interlimb phasing errors while mitigating loss of paretic limb work. However, participants adopted a suboptimal pedaling strategy and performance was not retained during Post-test. Aim 2 tested whether simple visual feedback could further reduce phasing error as well as mitigate suboptimal pedaling strategy and allow retention during Post. Additionally, a constant and randomly-varying error augmentation gain schedule was examined to determine whether pedaling could further be improved. Interestingly, neither simple visual feedback nor error augmentation improved performance. We hypothesized that simple visual feedback did not adequately provide saliency of the task goal relative to the displayed error. Thus, for Aim 3 we tested whether additional visual feedback elements of reward and punishment were sufficient to improve pedaling performance. Results indicated that participants do indeed improve pedaling performance when presented with simple visual feedback in addition to elements of reward and punishment. Overall, these studies demonstrate that CUped can provide a proper environment to promote therapeutic behavior as well as provide important knowledge about lower limb deficits after stroke needed to drive the development of CUped forward.