

Central and peripheral limits to exercise: lessons from FES-evoked leg exercise in spinal cord-injured individuals

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Individuals who have suffered a traumatic spinal cord injury (SCI) are usually confined to life in a wheelchair, with secondary medical sequelae that result from reduced physical activity. Two approaches currently exist to reverse loss of cardiorespiratory fitness in this population. Patients may undertake arm exercise or sporting endeavours using the remaining musculature in their upper body with the risk of provoking overuse injuries or shoulder pathologies that might restrict daily wheelchair propulsion. Alternatively, SCI individuals can undertake leg exercise using Functional Electrical Stimulation (FES), whereby computerised neuromuscular stimulation evokes muscle contractions to produce movements such as cycling, standing and stepping. However, for FES-evoked leg exercise, both “central” cardiovascular and “peripheral” muscle limitations confine the usual benefits associated with regular physical activity. From a cardiovascular control perspective, FES-exercise is induced without central command effectors on heart rate and blood pressure, so these physiological outcomes may be ‘blunted’ compared to voluntary leg exercise. During FES-cycling exercise “baroreceptor resetting” is absent and SCI individuals often demonstrate inconsistent heart rate responses during such exercise. FES-evoked leg exercise also proceeds in the absence of ascending Group III and IV neural feedback from the working muscles that normally contributes to cardiovascular control, due to the “blocking effect” of the spinal cord lesion. As well as to altered cardiovascular control, peripheral adaptations such to muscle atrophy, loss of vascularisation, a morphological shift to predominantly Type IIB fibres and associated histochemical changes result in leg muscles with high fatigue rates and poor power output. These peripheral adaptations can be somewhat reversed with habitual leg exercise, but it is unknown whether the central cardiovascular limitations to exercise (proceeding from impaired neurological reflex control) can be altered with regular FES-evoked cycling or stepping. The SCI individual undertaking FES-exercise provides a useful model to investigate the disparate central and peripheral limits to “the exercise response” in humans.