Efficiency of Functional Electrical Stimulation – Cycling: a comparative study

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Introduction

The effects of a spinal cord injury (SCI) significantly alter a person's life. Physically, the body undergoes a variety of changes, such as atrophy of the muscles and a reduction in bone mineralization below the degree of injury [1]. Muscles whose function has been compromised by SCI can be functionally restored by electrical stimulations (ES). Additionally, ES can create useful movements. Cycling is particularly well-liked for Functional Electrical Stimulation (FES) since it is a repetitive task-oriented training with simultaneous stimulations and leg movement. In this context, the project's goal is to assess the metabolic efficiency of FES-Cycling using three different devices (MOTOmed, CybaTrike and Go-Tryke) and to provide design ideas to enhance the performance and efficacy of this activity.

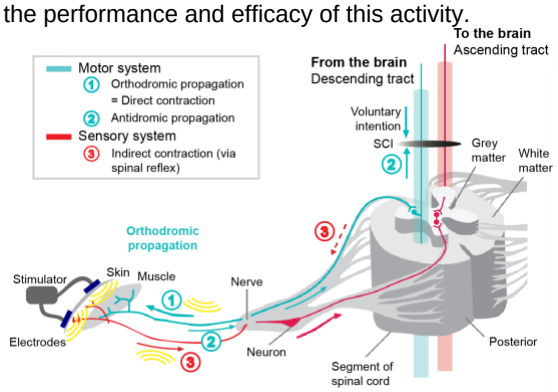

Fig. 1. FES activates motor and sensory nerve fibers and creates a direct and an indirect muscle contraction. Adapted from [2]. SCI = Spinal Cord Injury

Materials and Methods

This project intends to bring together several parameters to understand their influences and interactions during FES-Cycling. Firstly, for each participant, bike, and day, the metabolic efficiency is derived from the calculated mechanical Power Output (PO), the measured oxygen consumption, and the carbon dioxide production. In addition, the exercise intensity is analyzed using the oxygen uptake, heart rate, and an assessment of the perceived exertion computed according to the Borg RPE scale. Furthermore, leg muscle activity is recorded using electromyography. Finally, since one of the bikes used allows the whole body to move, the influence of arm activity can also be investigated.

Results

On the MOTOmed, it has been demonstrated that the metabolic efficiency is quite poor (device that rotates the legs, no transfer required) (Fig. 2). In contrast, the highest efficiency is on the CybaTrike (more lying position). Additionally, the Go-Tryke (which involves both arms and legs) induces a stronger physiological reaction, resulting in a higher heart rate and oxygen consumption. It is also noted that the muscular response to the ES and the PO are correlated.

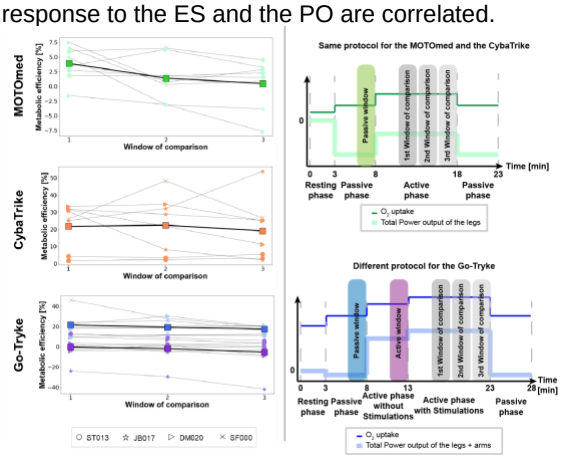

Fig. 2. Metabolic efficiencies results

Discussion

This project contributes to a better understanding of the different parameters that influence metabolic efficiency. Different approaches could also be developed to boost metabolic efficiency even more. Generally, higher stimulation parameters can be used in future studies. PO was higher on the CybaTrike than on the other bikes due to the higher angle between the hip-knee-foot. On the other hand, it is still possible to increase the PO during the stimulations by changing the seating position and the attachment of the legs. Finally, the metabolic efficiency was slightly lower on the Go-Tryke than on the CybaTrike due to smaller PO. To achieve a stronger power, the stimulations must be changed, perhaps by stimulating several muscle groups.

References

[1] G. Schalow, "2 partial cure achieved in a patient with near-complete cervical spinal cord injury (95% injury) after 3 years of coordination dynamics therapy.," Electromyography & Clinical Neurophysiology, vol. 49, no. 5, p. 199, 2009.
[2] Spinal Research, "What is spinal cord injury?." https://spinal-research.org/injury.

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