Comparison of strategies and performance of functional electrical stimulation cycling in spinal cord injury pilots for competition in the first ever CYBATHLON

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Abstract

Functional Electrical Stimulation (FES) can elicit muscular contraction and restore motor function in paralyzed limbs. FES is a rehabilitation technique applied to various sensorimotor deficiencies and in different functional situations, e.g. grasping, walking, standing, transfer, cycling and rowing. FES can be combined with mechanical devices. FES-assisted cycling is mainly used in clinical environments for training sessions on cycle ergometers, but it has also been adapted for mobile devices, usually tricycles. In October 2016, twelve teams participated in the CYBATHLON competition in the FES-cycling discipline for persons with motor-complete spinal cord injury. It was the first event of this kind and a wide variety of strategies, techniques and designs were employed by the different teams in the competition. The approaches of the teams are detailed in this special issue. We hope that the knowledge contained herein, together with recent positive results of FES for denervated degenerating muscles, will provide a solid basis to encourage improvements in FES equipment and open new opportunities for many patients in need of safe and effective FES management. We hope to see further developments and/or the benefit of new training strategies at future FES competitions, e.g. at the Cybathlon 2020 (www.cybathlon.ethz.ch).

Key Words: spinal cord injury, FES cycling, FES for denervated muscles, competition context, CYBATHLON

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Functional Electrical Stimulation (FES) can elicit muscular contraction and restore motor function in paralyzed limbs.[1,2] Furthermore, electrical stimulation, though know under different names, such as pace-maker or auditory implanted devices, provides successful clinical approaches that benefit millions of disabled individuals. FES is a rehabilitation technique applied to various sensorimotor deficiencies and in different functional situations, e.g., grasping, walking, standing, transfer, cycling and rowing.[3-5]. FES can be combined with mechanical devices.[6-8] FES-assisted cycling is mainly used in clinical environments for training sessions on cycle ergometers,[9-11] but it has also been adapted for mobile devices, usually tricycles.[12-14] In October 2016, twelve teams participated in the CYBATHLON competition in the FES-cycling discipline for persons with complete lower-limb spinal cord injury (SCI).[15] It was the first event of this kind and a wide variety of strategies, techniques and designs were employed by the different teams.[16-21] Seven teams were able to cover the 750 m distance of the race with timings ranging from 178 s to 467 s to complete the race. However, beyond the competition scores, the main achievement of this event was to highlight the potential of FES to provide exercise and fitness to a variety of people in a recreational setting. Pilots in the race were 21 to 59 years old and had lesions at levels from C4 to

T9. As participants in this competition, we believe it is important for our community to document the scientific and technological approaches used by the different teams in order to help advance our understanding of FES-cycle training and racing strategies. We therefore prescribed a number of important aspects to be analyzed by each team in order to allow for a synthesis and comparison between solutions and performance. The articles in this EJTM special issue, FES Cycling/Cybathlon, introduce case studies gathering multidisciplinary points of view and approaches. These case studies may serve as a starting point to overcome current and future challenges. FES cycling requires several weeks to months of physical preparation to improve the pedalling performance of SCI individuals to reach competition levels. FES cycling is also used in other situations including post-stroke hemiplegia and in the elderly.[10,22] Furthermore, FES cycling is a sport that can be practised by SCI individuals in whom permanent denervation results in degeneration of muscles (DDM). In the latter case, prevention and even recovery from muscle degeneration can occur if FES for DDM is performed at a 5-day a week training level for several months.[23-50]
We hope to see further developments and/or the benefit of new training strategies at future FES competitions, e.g. at the Cybathlon 2020 (www.cybathlon.ethz.ch).[51]

List of acronyms

EJTM – European Journal of Translational Myology
FES – Functional Electrical Stimulation
SCI – Spinal Cord Injury
DDM – denervated and degenerating muscle

Author's contributions

All authors designed, implemented and approved the typescript.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Publication Statement

The authors confirm that they have read the Journal's position on issues involved in ethical publication and affirms that this report is consistent with the guidelines of the EJTM.

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