Comparison of strategies and performance of functional electrical stimulation cycling in spinal cord injury pilots for competition in the first ever CYBATHLON
Christine Azevedo Coste, Vance Bergeron, Rik Berkelmans, Emerson Fachin Martins, Ché Fornusek, Arnin Jetsada, Kenneth J. Hunt, Raymond Tong, Ronald Triolo, Peter Wolf

To cite this version:

HAL Id: lirmm-01656814
https://hal-lirmm.ccsd.cnrs.fr/lirmm-01656814
Submitted on 6 Dec 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License
Comparison of strategies and performance of functional electrical stimulation cycling in spinal cord injury pilots for competition in the first ever CYBATHLON

Christine Azevedo Coste (1), Vance Bergeron (2), Rik Berkelmans (3), Emerson Fachin Martins (4), Ché Fornusek (5), Arnin Jetsada (6), Kenneth J. Hunt (7), Raymond Tong (8), Ronald Triolo (9), Peter Wolf (10)

(1) INRIA / LIRMM, Montpellier, France; (2) ENS Lyon, France; (3) Berkelmans, BerkelBike BV, Netherlands; (4) NTAAI / UnB, Brasília, Brazil; (5) EXSS, University of Sydney, Australia; (6) Department of Biomedical Engineering, Mahidol University, Thailand; (7) Institute for Rehabilitation and Performance Technology, Bern University of Applied Sciences, Switzerland; (8) Dept of Biomedical Engineering, The Chinese University of Hong Kong, China; (9) Case Western Reserve University and the Louis Stokes Cleveland Veterans Affairs Medical Center, Cleveland, USA; (10) Sensory-Motor Systems Lab, ETH Zurich, Switzerland

This article is distributed under the terms of the Creative Commons Attribution Noncommercial License (CC BY-NC 4.0) which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

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

Functional Electrical Stimulation (FES) can elicit muscular contraction and restore motor function in paralyzed limbs. 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. 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 complete lower-limb spinal cord injury (SCI). It was the first event of this kind and a wide variety of strategies, techniques and designs were employed by the different teams. 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.73-30

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)31.

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.

Acknowledgments
The authors thank the EJTM Journal for accepting to publish this special issue. This typescript was sponsored by the A&C M-C Foundation for Translational Myology, Padova, Italy.

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.

Corresponding Author
Christine Azevedo Coste, INRIA / LIRMM, Montpellier, France. E-mail: Christine.azevedo@inria.fr

E-mails of co-authors
Vance Bergeron: vance.bergeron@ens-lyon.fr
Rik Berkelmans: rik@berkelbike.com
Emerson Fachin Martins: emersonontai@gmail.com
Ché Fornusek: che.fornusek@sydney.edu.au
Arnin Jetsada: jetsada.arn@mahidol.ac.th
Kenneth J. Hun: Kenneth.Hunt@bfh.ch
Raymond Tong: kytong@cuhk.edu.hk
Ronald Triolo: ronald.triolo@case.edu
Peter Wolf: peter.wolf@hest.ethz.ch

References


29. Korn H, Rossini K, Carraro U, et al. Muscle biopsies show that FES of denervated muscles reverses human muscle degeneration from

EJTM Special: FES Cycling/CYBATHLON
Eur J Transl Myol 27 (4): 251-254