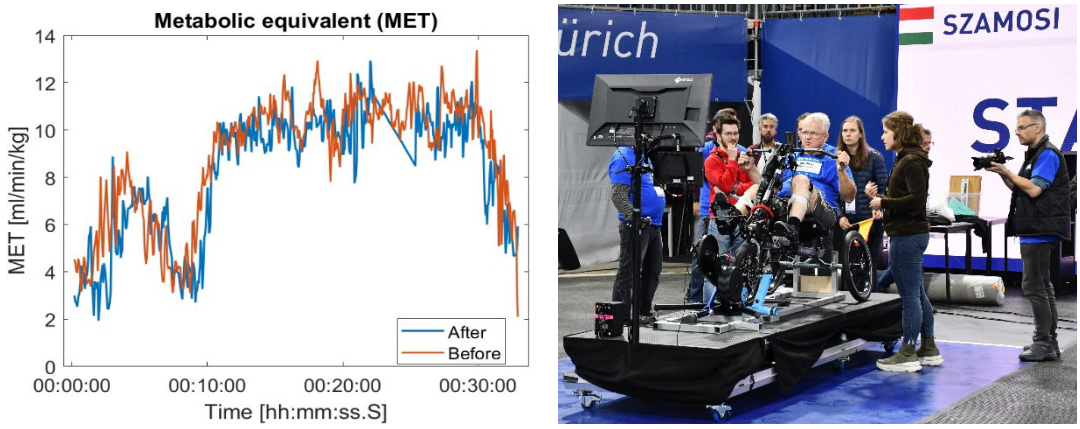
2024

Influences of Cybathlon FES bike race preparation on the pulmonary system.

The Cybathlon competition will introduce (Functional Electrical Stimulation) FES cycling as a competitive event that, in addition to its therapeutic effect, will provide motivation and the opportunity to develop a personalised training protocol for the pilot with spinal cord injury. Our research team also participated in this race and during the preparation phase, we investigated the effects of training with the FES race framework on the respiratory system of our pilot. We also compared the race setup with previously used training formats. Three training protocols were utilized: i) outdoor training sessions, where the pilot cycled on a track using a tricycle equipped with a multichannel electrical stimulator, ii) indoor sessions when the tricycle was placed on a roller without resistance. iii) indoor when the tricycle on a roller was extended with Wahoo Kicker cycling trainer and other sensors. This was the race framework. Indoor workouts without resistance allow for significantly higher average speeds compared to outdoor sessions and those conducted on the Wahoo trainer. The consistency of the peak VO2 after training with the race setup indicates a consistent metabolic demand while the vital capacity enlarged by 0.8L. After four months our pilot was capable to adapt workouts on Wahoo and his pulmonary system get used to these exercises and improved his vital capacity to be able cycling in harder conditions more continuously and as fast as he was on the track field. The race setup allows performance training and simulates real cycling settings in an indoor environment. This framework extends beyond race to the application of rehabilitation protocols.[1]



- **Figure 1.** *On the left panel, Metabolic equivalent (MET) is a measure that shows that how much oxygen is needed for a physical activity per minute. At the 'before' assessment, that was taken before the indoor training with the Wahoo trainer started, the maximum of MET was 9 ml/min/kg during arm cycling warm up (Figure 1., "Before", min 0 till 10). Then it dropped in the resting phase and started to increase rapidly when FES driven cycling started. The average MET was 10.33 ml/min/kg, and the maximum was 13.37 ml/min/kg. At the 'after' assessment the MET values progressed similarly to the 'before' values, the average MET during FES driven cycling was 9.67 ml/min/kg, and the maximum was 9.93 ml/min/kg. The right panel shows the pilot on the FES tricycle with the race frame at the Cybathlon2024 Competition.*

Kinesiological gait parameter changes in two incomplete spinal cord injured patients due to hybrid arm and leg cycling therapy – pilot study — We studied the influence of hybrid FES cycling (controlled voluntarily by the arms and by Functional Electrical Stimulation in the paralyzed legs) training supplemented rehabilitation on the walking ability of two incomplete spinal cord injured participants (P1, P2). The training lasted 12 weeks with 2 sessions per week. We performed gait assessment before and after the training. We measured the kinematics and muscle activities of the patients' lower limbs. We calculated the knee and ankle joint angle ranges and plotted the average time normalized profile of the muscle activities. Knee muscle activities increased from the beginning to the end of the training (Fig 2. Panel: C). At the end of the training, the range of the knee and ankle angles for the first participant increased (Fig 2. Panel: A), and for the second participant became more balanced comparing the sides (Fig 2. *Panel: B*). These results support the assumption that hybrid FES cycling training helps to improve spinal cord injured participants' walking ability.

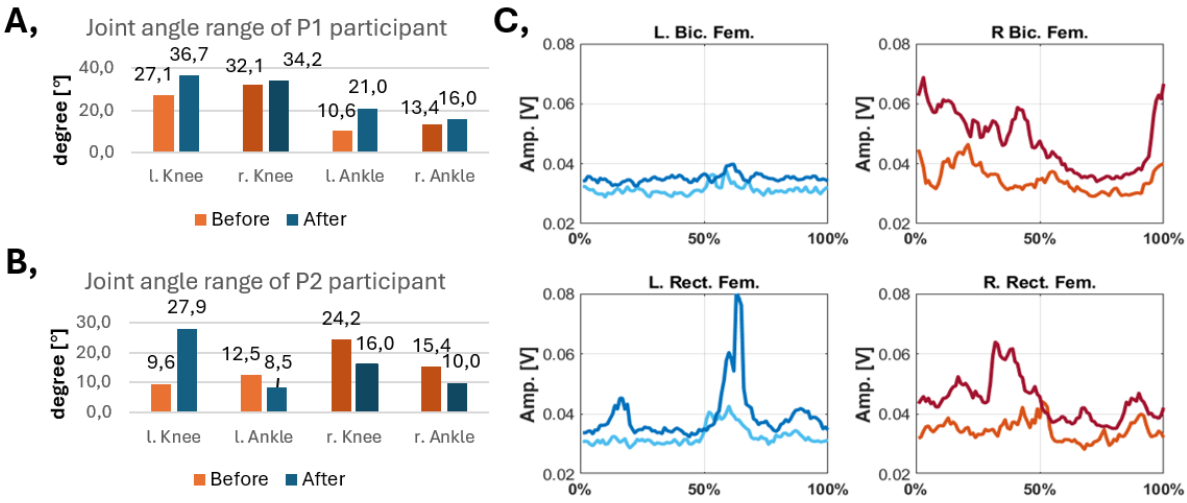


Figure 2. *Panels **A** and **B** show the volume of joint angle range of P1 and P2 participant before and after the 12 weeks long rehabilitation training program which additionally contained hybrid FES cycling training. Panel **C** shows the examples of time normalized EMG envelopes of Biceps Femoris and Rectus Femoris muscles in one step cycle of P2. Light blue and orange colors denote the initial condition of the participant. The dark blue and red denote the outcome after the training.*

References (choose maximum 5 articles, each must begins with https://):

[1] A. Fodor et al. : Influences of Cybathlon FES bike race preparation on the pulmonary system , IFESS2024, Bath, *in: Artificial Organs*, vol 49/1, publ: 31.dec.2024, https://doi.org/10.1111/aor.14902

[2] B. Radeleczki et al.: Kinesiological Gait Parameter Changes in Two Incomplete Spinal Cord Injured Patients Due to Hybrid Arm and Leg Cycling Therapy – Pilot Study, In: Pons, J.L., Tornero, J., Akay, M. (eds*) Converging Clinical and Engineering Research on Neurorehabilitation V. ICNR 2024*. Biosystems & Biorobotics, vol 32., Springer, Cham. https://doi.org/10.1007/978-3-031-77584-0_4

[3] L. Botzheim et al.: Jerk analysis of gait in persons with incomplete spinal cord injury: a study about the effect of hybrid arm and leg cycling, in *International Scientific Conference Motor Control 2024 From Theory To Applications Book of Abstracts*, 2024, pp. 16–16., https://motorcontrol.pl/wp-content/uploads/2024/09/MC202024-BOOK-OF-ABSTRACTS-Speaker-17.09.pdf