The development of a hybrid outdoor FES bike

Rik Berkelmans*1, Martijn Arns2, Jacques Duysens3

1 Berkel Bike B.V., Nijmegen, The Netherlands, 2 BraInquiry – Europe C.V., Nijmegen, The Netherlands 3 St. Maartenskliniek Research B.V., Nijmegen, The Netherlands

Introduction

After the introduction of the stationary FES bike 20 years ago, there have been several attempts to build an outdoor FES bike for spinal cord injured patients [1,2,3,4,5]. One of the problems faced by these groups was the lack of produced power output and stamina by the FES stimulated legs. Another problem is the bad manoeuvrability of a tricycle when compared to a wheelchair.

In 2000 a private initiative by Berkelmans was initiated. The goal was to design a FES bike to overcome these and other problems. Shortly after the start of this project, the St. Maartenskliniek (a renowned rehabilitation clinic) joined the project. For the technical, electronics and software development of the bike, an extensive network of companies and institutions where involved.

Method

The Berkel Bike (the name of this FES bike) is a mixture of a ‘clamp on hand bike’ and a recumbent bike. The front part of the Berkel Bike can be attached to most available wheelchairs, increasing acceptability by users and freedom of movement. An inflatable pillow behind the back gives the user a more recumbent position, necessary to enable the cycling movements from the legs. When the arm cranking is started the legs will make passive cycle movements until FES is initiated.

Around the crank axle a goniometer is placed which measures the position of the pedals in 256 steps. On the basis of this information the quadriceps, hamstrings and glutaeus are stimulated. The 12 stimulation electrodes are placed inside the shorts and can be worn underneath trousers. During cycling the rider can control the intensity of the stimulation by a +/- switch. A higher level of control is achieved by connection to a handheld/PDA. This is particularly useful when the Berkel Bike is used as a stationary bike. To convert the outdoor bike to a stationary bike the front wheel is placed in a holder with an electrical roller brake against the tire.

Results

Most paraplegics can use the latest prototype independently. They can reach the same speed as with normal clamp-on hand bikes. They can reversely uncouple the front part, which allows them to use their wheelchair.
Discussion

Due to the satisfying results, a trial will be started in May. Ten Berkel Bike’s will be provided to spinal cord injured patients. They have to use the bike for at least 3 x 20 min a week. Every 2 months they visit the St. Maartenskliniek and the University of Nijmegen in order to perform some tests. The main goal is to make the Berkel Bike ready for market introduction. A second goal is to monitor some physiological and functional changes due to hybrid and FES cycling. Some of the physiological parameters assessed are: muscle mass, body composition, VO₂ max, power output and some respiratory and vascular parameters. The testing of functional changes will be performed with a test protocol derived from the Dutch “Koepelproject”. This project follows more then 200 SCI patients up to 1 year after leaving the rehabilitation centre. The database of this project will serve as comparison material.

The third goal is to investigate previous observations that SCI patients are still able to exert some form of voluntary control during FES-cycling. It was observed that some SCI patients improved performance on FES cycling by paying ‘attention’ to it. Central to this hypothesis is the concept of Central Pattern Generators (CPG’s) This part of the study will serve to investigate which physiological system is responsible for initiating these CPG’s beneath the injury; neurohormonal substances; other ‘non-spinal’ neuronal innervations (such as Nervus Vagus innervation) etc. For this part of the study a collaboration with BrainInquiry – Europe C.V has been established.

In conclusion, after 2 ½ years of development the prototype of the Berkel Bike is ready for the last step to the market.

References


Note 1: The concept of the Berkel Bike is patented.
Note 2: More information is available on www.berkelbike.nl.
Acknowledgments: The author wishes to acknowledge the National Rehabilitation Foundation (NRF), Senter, ESKAN and Innovation With Care (IMZ) for sponsorship of this research.