

## **Postural strategies emerging in complete paraplegic patients verticalized with functional electrical stimulation**

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### Introduction

Functional electrical stimulation (FES) allows for performing standing in complete paraplegic patients. Benefits of an active verticalization are both psychological and physiological. FES creates a split-body situation where the body is in part controlled externally, whereas the rest of the body remains under the voluntary influence of the central nervous system. Nevertheless, the patient has an indirect action on his lower body through the closed mechanical chain going from hand supports to feet. This study aims at understanding the coordination patterns between upper and lower body in order to ensure postural balance. In valid subjects, regardless of disturbances, 2 stable postural patterns seem to emerge : a phase mode where hips and ankles' angles go in a same direction and an anti-phase mode where hips and ankles' angles go in opposite directions.

### Methods

Patients suffering from complete spinal cord lesion were equipped with surface electrodes delivering electrical stimulation to 4 muscular groups in each leg, ensuring that 1) lateral movements of pelvis were stabilized; 2) knee were locked; 3) ankle were free to rotate. The stimulation sequences were parameterized offline and pre-programmed for each patient. The protocol was to stand in between parallel bars and maintain postural balance by aligning head, pelvis and ankles. In order to help patients in adopting the correct posture, a visual feedback assistance was provided ; a screen was set up in front of the patients where they could see their own profile. A video motion analysis system recorded the positions of 16 passive markers. 6-degree of freedom force sensors were fixed on the handles to record upper limbs' efforts on the parallel bars. Insoles were placed inside the patient's shoes to record pressure distribution. Patients were trained to FES technique in a lying position during the 1st week followed by 2 days of rest. The 1st day after this conditioning, they were familiarized with the verticalization protocol. We started recording data from the 2nd day on. 5 try-outs of 1mn-standing were performed by each patient.

## Results

The data analysis focused on windowed crosscorrelations between absolute angles, of upper and lower limbs. The observed coordination modes were evaluated through their occurring frequency and efficiency. Efficiency was estimated based on the normalized efforts applied by the patients on the handles. The more the patients were supporting their weight on their arms the lesser efficient was the posture. Despite the patient group being heterogeneous (lesion level and time since injury) and despite the significantly different efforts they applied on the handles, it seems that the anti-phase mode is the most frequently used by the patients, and also the most efficient. Nevertheless, this mode remains unstable as it is not maintained over the trials.

## Conclusions

Stabilizing the anti-phase mode by training should improve efficiency of vertical posture and increase the functionality of standing.

**KEYWORDS:** Rehabilitation, Movement disorders, Stimulation, Dynamical systems.