Model Predictive Control (MPC) for Enhancing Building and HVAC System Energy Efficiency: Problem Formulation, Applications and Opportunities

Straight-path and U-turn gait biomarkers in PD patients before and after deep-brain stimulation

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Introduction

Clinical gait analysis revealed that turnings are altered, even in the early stages of Parkinson's Disease (PD), with increased turning arcs, time to complete the turn, and a larger number of steps taken to complete the turn. Furthermore, turning/curved walking is more likely to cause gait instabilities and increased variability compared to straight walking. Many studies focus on repeated trials of short intermittent walking bouts, while there is a lack of works considering continuous and prolonged overground walking, that includes both straight-path and turnings. However, this latest approach seems promising to obtain sensitive and reliable gait biomarkers recorded in ecological walking conditions.

Methods

This study enrolled 20 PD patients and 20 healthy controls. PD patients were tested twice: before Deep-Brain-Stimulation (DBS) neurosurgery, and 3 months after it [1]. All subjects were asked to walk for 5 minutes back and forth a straight path, and to U-turn for changing direction at the end of the 9-m walkway. Foot-floor contact events were directly detected by means of footswitches. Besides traditional gait parameters, the percentage of "non-standard" gait cycles was analyzed, i.e., cycles showing a sequence of foot-floor contact events different from the typical one (heel-strike/flat-foot-contact/push-off/swing), normalized with respect to the walking speed [2].

Results

Overall, PD patients considerably improved their gait after DBS, as represented in **Figure 1**.

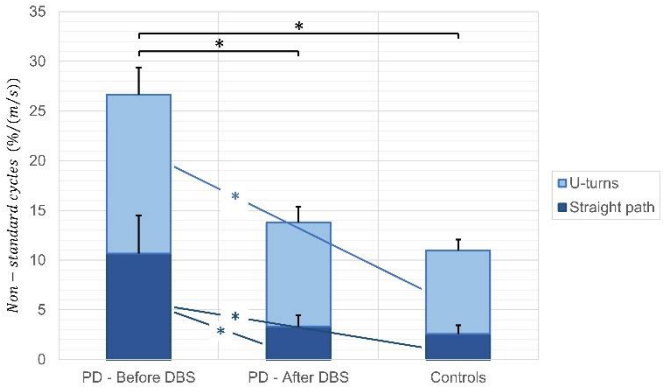

Figure 1. Stacked bar diagrams of the normalized percentage of "non-standard" gait cycles in the more affected side of PD patients (before and after DBS) and in the dominant side of controls. Asterisks represent statistically significant differences (p-values < 0.05). Error bars represent the standard errors.

Discussion

The percentage of "non-standard" gait cycles (also called "atypical" gait cycles) already proved to be an accurate biomarker for quantifying subtle gait dysfunctions in PD patients, correlated with the clinical score UPDRS-III [2]. The present work demonstrated the validity of this parameter in the evaluation of the effects of the DBS, at 3 months after the implant. The segmentation of straight-path and U-turning epochs [3] provided supplemental information, that can be useful in the management of PD patients. While the PD neuromuscular control after DBS was already analyzed in a recent work [1], this is the first contribution presenting original gait analysis data on this cohort of patients.

REFERENCES

[1] Ghislieri M. *et al.* "Muscle synergies in Parkinson's disease before and after the deep brain stimulation of the bilateral subthalamic nucleus". *Scientific Reports*, 2023; 13:6997.

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[3] Ghislieri M. *et al.* "U-Turn Detection during Walking". *2022 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*, 2022; pp. 01-05.