Clinical Feasibility Evaluation of a Feedback Control System for Heart Rate in Patients After Stroke

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Introduction

Stroke stands as a prominent contributor to both mortality and disabilities on a global scale. The process of rehabilitation therapy holds a significant role in addressing impairments and disabilities linked to stroke [1]. As a means to further this endeavour, robotic rehabilitation devices have been developed and employed to augment conventional rehabilitation therapy.

This work investigated the feasibility of employing a feedback control system for heart rate. The integration of heart rate control algorithms into rehabilitation devices holds the potential for enhancing the supervision and regulation of patients' physiological responses during exercise.

Materials and Method

Twelve stroke patients with disability levels ranging from mild to severe were recruited and performed heart rate control exercises using a modified robotic tilt table (Erigo, Hocoma AG, Volketswil, Switzerland). Heart rate dynamics were individually identified and patients' heart rates were stabilized for an exercise duration of 20 minutes. Figure 1 illustrates a schematic heart rate feedback control system. Heart rate control was implemented based on the premise that patients would align their work rate with a target reference. This target reference was then continuously adjusted to modulate and guide the heart rate.

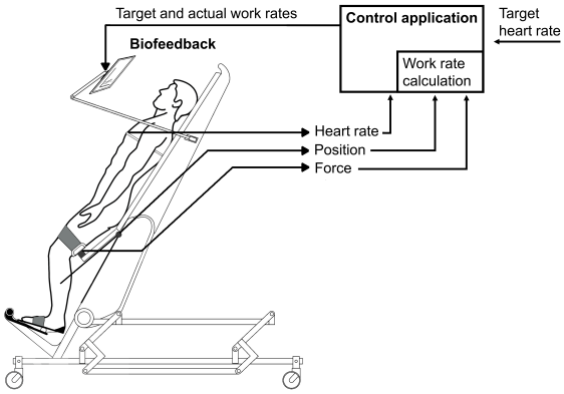

Figure 1: Robotics-assisted tilt table with a schematic heart rate feedback control system (Reused with permission and modified after [2])

Results

Eleven out of the twelve heart rate control exercises were successfully conducted. The technical implementation was proven effective, and patients grasped the core concept of heart rate control, intuitively adjusting their effort to align with the desired target work rate. On average, the target heart rate was set to 94 bpm (this corresponds to 57% of the age-related maximal heart rate) and the control exercises were completed with a root-mean-square error of 1.78 bpm.

Discussion

This study establishes that heart rate control exercises carried out with stroke patients on the Erigo robotics-assisted tilt table are fundamentally feasible. Due to the inherent feedback loop mechanism, active patient participation is guaranteed. However, it is worth noting that the potential of this approach is restrained by the small heart rate activation of the exercise modality. Exploring alternative modalities with an improved heart rate response could relax the imposed restrictions and enhance the overall applicability of heart rate control.

References

[1] Winstein, C. J. *et al.*, Guidelines for adult stroke rehabilitation and recovery: A guideline for health-care professionals from the american heart association/american stroke association. *Stroke*, 47(6):e98–e169, 2016. doi: 10.1161/STR.0000000000000098.

[2] Saengsuwan, J. *et al.*, Submaximal cardiopulmonary thresholds on a robotics-assisted tilt table, a cycle and a treadmill: a comparative analysis. *Biomed Eng Online*, 14:104, 2015. doi: 10.1186/s12938-015-0099-0

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