Chronic Heart Failure, Treatment, Rehabilitation

Restoring the circadian clock in heart failure patients using cardiac telerehabilitation

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Background: Heart failure (HF) affects millions globally, posing severe healthcare challenges. Disrupted circadian rhythms, driven by dysregulated molecular clocks, are increasingly linked to disease progression in HF [1]. Under normal conditions, cardiac physiology follows circadian patterns set by a 'master pacemaker' in the suprachiasmatic nucleus, influencing heart rate (HR), blood pressure, and autonomic function [1]. Identifying and restoring circadian rhythms in HF patients may improve clinical outcomes, optimizing both therapeutic timing and autonomic regulation. Telerehabilitation shows promise in preserving or re-establishing circadian functions critical for cardiac health, potentially serving as a novel intervention for HF management.

Objective: This study investigates whether cardiac telerehabilitation (CTR) can restore circadian patterns in patients with HF, hypothesizing improvements in autonomic regulation and overall clinical outcomes. We explored the impact of CTR on circadian rhythm parameters mesor, amplitude, and acrophase derived from continuous HR monitoring.

Methods: In this two center, prospective, randomized controlled trial, patients recently hospitalized for acute decompensated HF were randomized into two groups: an intervention group undergoing an 18-week CTR program comprising exercise training, dietary guidance, and mental health support, and a control group receiving standard care. Digital monitoring was enabled via a smartwatch, with six months of HR data collection. Circadian rhythms were analysed through cosinor analysis, employing a generalized linear model with gamma distribution to estimate mesor, amplitude, and acrophase from hourly-averaged HR data (Fig. 1) [2]. Intra- and inter-group comparisons were conducted using paired and independent t-tests.

Results: For 25 participants in the control group and 28 in the intervention group digital monitoring data was available for analysis. Baseline demographic and clinical characteristics showed no significant differences, ensuring comparability. Significant within-group changes were observed in the intervention group following CTR, with decreases in mesor from 71.53 to 64.15 BPM ($p<0.01$) and increases in amplitude from 8.19 to 13.03 BPM ($p<0.001$), suggesting enhanced circadian rhythm regularity and improved cardiovascular fitness. Post-intervention, the intervention group showed significantly lower mesor (64.15 BPM vs. 69.41 BPM, $p<0.01$) and higher amplitude (13.03 BPM vs. 8.56 BPM, $p<0.001$) compared to the control group, while acrophase remained unchanged (Fig. 2).

Conclusion: This study showed that comprehensive CTR can restore physiologic circadian rhythm parameters in patients with HF. By realigning the circadian clock and its related autonomic responses, there is potential to enhance (cardiovascular) health outcomes. Future research should identify the optimal rehabilitation routines to achieve circadian alignment, ultimately leading to improved cardiovascular health.

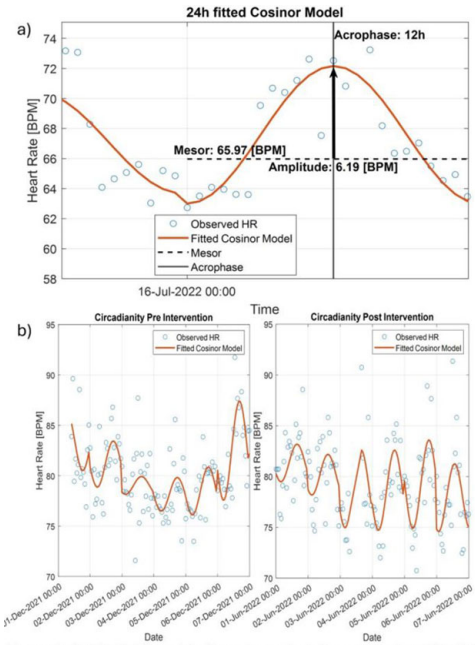

Figure 1: (a) Definition of rhythm characteristics on cosinor-fitted HR data of a HF patient. The mesor is the rhythm-adjusted mean; the amplitude measures the extent of predictable change within a cycle; the acrophase measures the timing of the maximum circadian rhythm peak. **(b)** Cosinor analysis of circadian rhythm in a representative intervention patient, both pre- and post-CTR.

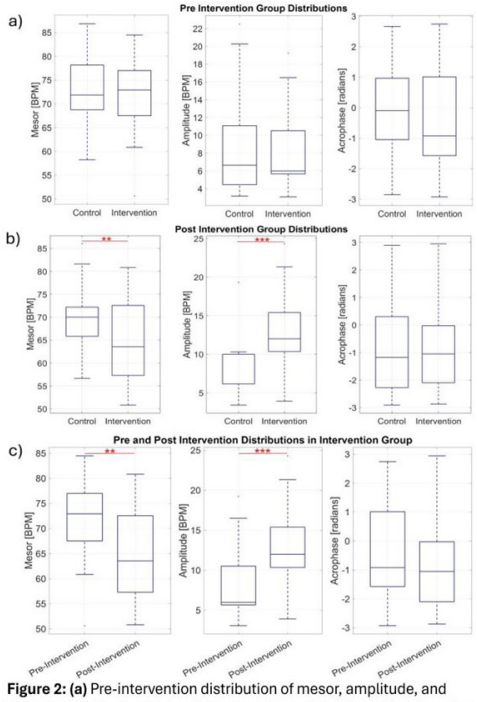

Figure 2: (a) Pre-intervention distribution of mesor, amplitude, and acrophase in the control and intervention groups. **(b)** Post-intervention distribution of mesor, amplitude, and acrophase comparing control and intervention groups (**p<0.01, ***p<0.001 from independent t-test). **(c)** distribution of mesor, amplitude, and acrophase within the intervention group, both pre- and post-intervention (**p<0.01, ***p<0.001 from paired t-test