# Monitoring the association between movements and heart rate changes during sleep: feasibility of a multi-sensor wearable system setup

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**Introduction**: Sleep significantly impacts cardiovascular control, with heart rate (HR) during sleep indicating autonomic nervous system function. Wearable technology allows for unobtrusive monitoring of cardiac and motor function during daily life, including sleep. This study explored the feasibility of monitoring HR changes associated with different sleep-related movements using a multi-sensor wearable system in a sample of healthy adults. **Methods**: Nine volunteers (30.1 ± 5.6 years) were monitored during sleep, using five accelerometers (AX6, Axivity Ltd, UK) at both wrists, ankles, and lower back and a wearable ECG chest strap (H10, Polar Italy), streaming raw ECG data to a smartphone via a custom app. Movements were detected with a custom threshold-crossing algorithm based on the envelopes of the accelerometer signal magnitude vector (SMV) over time, and their extent was quantified using tertiles of the area under the curve of the SMV envelopes. Movements were categorized based on the number of limbs involved, extent, and co-occurrence of changes in body position (i.e., supine, prone, or lateral). Changes in cardiac control associated with movements were assessed based on the HR changes compared to the pre-movement baseline. **Results**: Single-limb movements resulted in biphasic minor changes (increases followed by decreases) in HR. Movements involving all sensors were associated with monophasic, higher, and longer-lasting increases in HR when occurring with changes in body position (Fig. 1). Movements of a greater extent generated larger increases in HR, both in amplitude and duration. **Discussion**: Our study demonstrates the feasibility of using wearable systems to monitor cardiac correlates of sleep-related movements. Our findings reveal a dose-response relationship between movements and HR during sleep, with larger movements invoking stronger cardiac responses. Movement-related HR patterns identified in this study have the potential to be developed into biomarkers of sleep or cardiovascular disorders detectable with continuous monitoring with a multi-sensor wearable setup.

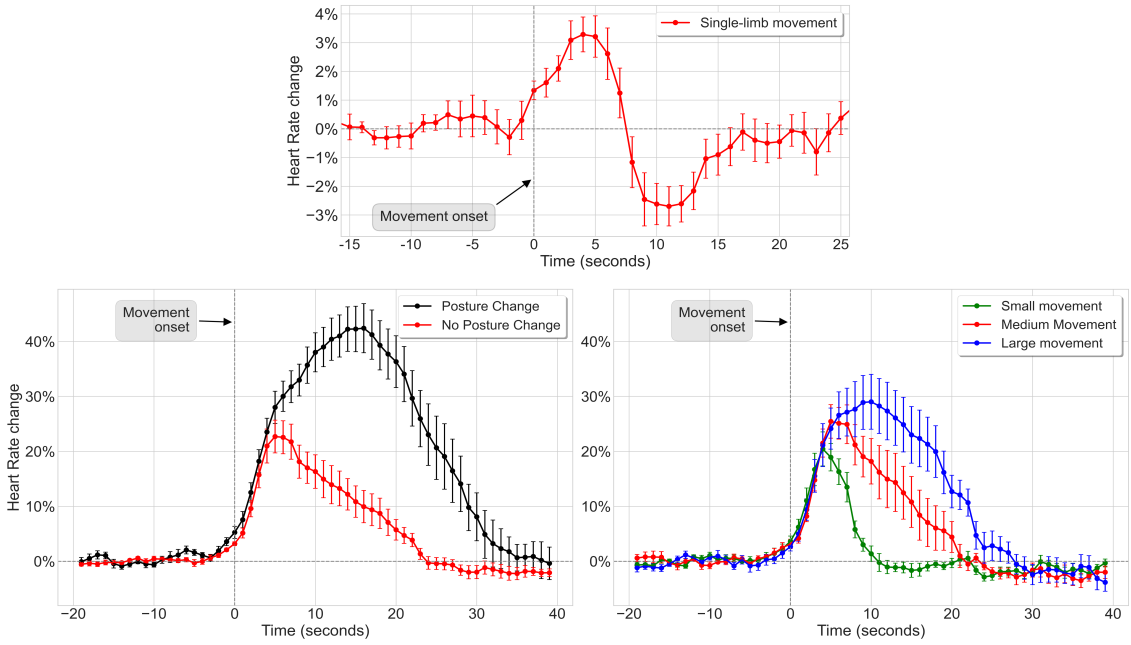


Figure 1. Time–course of cardiac activation associated with different types of sleep-related movements. Top: HR changes associated with single-limb movements (either wrist or ankle). Bottom left: comparison between HR response during changes in body position and no changes in body position. Bottom right: comparison between HR changes following large, medium, and small movements. HR values are expressed as mean ± standard error of the mean of changes from baseline (grand averages between subjects).