0102

PERFORMANCE EVALUATION OF A 24-HOUR SLEEP-WAKE STATE CLASSIFIER DERIVED FROM RESEARCH-GRADE ACTIGRAPHY

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Introduction: Wrist-worn research-grade actigraphy devices are commonly used to identify sleep and wakefulness in freely-living people. However, common existing algorithms were developed primarily to classify sleep-wake within a defined in-bed period with PSG, and exhibit relatively high sensitivity (accuracy on sleep epochs) but relatively low specificity (accuracy on wake epochs). This classification imbalance results in the algorithms performing poorly when attempting to classify data that does not have a predefined sleep period, such as over a 24-hour interval. Here, we develop a 24-hour actigraphy classifier to overcome limitations in specificity (accuracy on wake epochs), which typically afflict in-bed focused algorithms.
Methods: Four datasets scored via either PSG or direct observation of daytime wakefulness were combined (n=52 participants of mean age 49.8yrs, age range 19 - 86; 52% male; 221 total days/nights). Actigraphy (counts) and PSG (RPSGT-staged epochs) were temporally aligned. A model was trained to transform a time-series actigraphy counts to a time series of sleep-wake classifications, using the TensorFlow library for Python. 5-fold cross-validation was used to train and evaluate the model. Classification performance was compared to the output of the Spectrum device (Philips-Respironics) using the Oakley algorithm with a wake threshold of 'medium'.
Results: The developed classifier was compared to the Spectrum classifications across the 24-hour intervals. The developed classifier had higher accuracy (95.4% vs. 76.8%), higher specificity (95.9% vs. 68.9%) and higher balanced-accuracy (95.2% vs. 81.6%) relative to the Spectrum classifications, each assessed via paired-sample t-test. Sensitivity did not statistically differ (94.5% vs. 94.4%).
Conclusion: The model trained and evaluated on 24-hour data outperformed the existing algorithm output in terms of overall accuracy, specificity, and balanced accuracy, while sensitivity did not significantly differ. A model trained on 24-hour data may be more appropriate for analyses of freely living people, or older populations where napping is more common. Developing an accurate 24-hour sleep/wake classifier fosters new opportunities to evaluate sleep patterns in the absence of self-reports or assumptions about time in bed.
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0103

FEASIBILITY OF EXAMINING COMPONENT-SPECIFIC EFFECTS OF YOGIC BREATHING ON HEART RATE VARIABILITY DURING SLEEP: A THREE-ARM PILOT RCT

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0**Introduction:** Wearable devices and mind-body interventions (MBIs) continue to receive widespread interest as tools for improving sleep. This study investigated the feasibility of using an automated electronic survey system and wearable heart rate (HR) monitor in the context of a fully remote clinical trial study to produce detailed measures of participant adherence, daily sleep quality, and associations with physiological outcomes captured by wearable devices.
Methods: Eighteen healthy participants (age 18-30yrs, 12 female) were randomized to one of three 8-week long interventions: slow-paced breathing (SPB, N=5, 24.6 ± 2.1 years, 4 female), mindfulness (M, N=6, 23.7 ± 3.7 years, 4 female), or yogic breathing (SPB+M, N=7, 24.3 ± 3.1 years). Participants completed two weeks of daily sleep logs prior to a virtual laboratory visit, consisting of a 60-min intervention-specific training with 20-min guided practice, and subsequent tasks including experimental stress induction. Participants started a 24-hour HR recording using a Polar H10 chest strap on the night prior. Then, participants were instructed to repeat their assigned intervention practice daily, using a guided audio similar to their initial training, while concurrently recording HR data and completing a detailed practice log. HR interbeat interval data were examined with spectral analysis using full spectrograms for inspection of timecourse and frequency-specific patterns in both the nocturnal recordings and daily practice sessions.
Results: Participants completed an average of 75% of daily practice sessions across the 8-week intervention period (SPB: 77%, M: 65%, SPB+M: 77%). An automated procedure was developed to analyze and visualize the timecourse of HRV-derived breathing patterns in the 754 completed practice sessions and 36 nocturnal recordings. The three groups were then successfully distinguishable based on breathing rates and mindfulness questionnaires. Nocturnal HR recordings demonstrated visually identifiable patterns of interindividual variability and intraindividual consistency. Statistical analysis is ongoing to further characterize these patterns.
Conclusion: These findings support feasibility for a fully remote, semi-automated clinical trial study assessing component-specific effects of these MBIs on sleep, including detailed spectral analysis of high-quality HR data. Future studies would benefit from examining scalability of this type of study design with wearable physiology in both clinical and nonclinical populations.
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0104

ACOUSTIC ENHANCEMENT OF SLOW-WAVE SLEEP IN HEALTHY ADOLESCENTS

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Introduction: Adolescents have a stable sleep-need of between 9-10 hours a night, yet a pattern of markedly restricted sleep duration, particularly on school nights, has given rise to an epidemic of sleep deprivation in this population. As demonstrated by large numbers of studies, insufficient, irregular, and/or poor-quality sleep is a risk factor for both mental health problems and learning difficulties. Enhancing slow-wave sleep through non-pharmacological means may be a mechanism for alleviating daytime functional deficits in youth. In this study, we tested the feasibility of enhancing slow-wave sleep in healthy adolescents using a closed-loop, sleep-wearable device (SmartSleep, Phillips-Respironics) which monitors the EEG signal to automatically detect sleep stages, slow-waves, and micro-arousals to deliver acoustic stimulation to enhance SWA.
Methods: Seventeen healthy adolescents (15.5±1.8 years; 11 female) who endorsed sleep restriction and symptoms of daytime sleepiness participated in a randomized, cross-over study. Participation

included wearing SmartSleep for two consecutive 4-night periods at home—one period with acoustic stimulation (STIM) and one without (SHAM). During STIM, SmartSleep monitors the EEG in real-time and delivers acoustic tones (50 ms, 1 second interval between) through embedded headphones at an intensity dynamically modulated by sleep depth. Stimulation is stopped when an arousal or sleep stage-shift is detected. During SHAM recording, the same stimulation protocol is applied with tones played at zero volume.

Results: No differences were observed in any measure of sleep architecture. A mixed effects linear regression model was used to analyze the impact of condition (STIM vs SHAM) on both cumulative and average SWA during N2N3 and N3 sleep. At the group level, cumulative SWA during N2N3 and average SWA during N3 were significantly increased in STIM relative to SHAM ($p=0.01$; $p=0.02$, respectively), while age ($p=0.67$) and sex ($p=0.71$) had no effect. Despite the significant group effects, not all youth were responders; an average increase in cumulative SWA ($11.5 \pm 7.1\%$) in the STIM condition was observed in 12/17 participants.

Conclusion: Consecutive nights of acoustic stimulation enhanced SWA in otherwise healthy, sleep-restricted adolescents. These data suggest that acoustic stimulation during sleep may be a viable method for optimizing slow-wave activity and minimizing the emotional and cognitive consequences of sleep restriction during this sensitive developmental period.

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