

Performance of a Wireless Dry Sensor System in Automatically Monitoring Sleep and Wakefulness

Stephan E Fábregas¹, Jack Johnstone², John R Shambroom¹

¹Zeo, Inc, Newton, MA, USA ²Valley Sleep Center, Burbank, CA, USA

Introduction:

The ability to wirelessly monitor and track sleep and wakefulness in a way that is non-invasive and inexpensive could be of utility in many areas, including research, medicine, and education. One system with the potential to effectively accomplish this has been developed, which is composed of a single channel no-prep dry fabric sensor that rests on the forehead through the use of a headband. Data are then wirelessly transmitted to an accompanying base station and processed through a neural network to determine periods of sleep and wakefulness. This study was conducted to assess the accuracy of derived measures of this wireless system (WS) and Actigraphy (ACT) in comparison to polysomnography (PSG).

Methods:



Participants:

- 10 adults (4 female)
- 33.7 years old (± 10.7 ,SD)
- No sleep complaints

Study Protocol:

- Sleep in the laboratory at the participant's habitual bedtime
- Concurrent measurement of PSG, WS, and ACT
- PSG data collected with Cadwell Easy II PSG, sampled at 200 samples per second
- WS data were sampled at 128 samples per second
- ACT data were collected on a Mini-Mitter Actiwatch 64, epoch length set at 30 seconds
- Sleep records were scored by 2 trained technicians (T1 and T2) according to Rechtschaffen & Kales
- Sleep records were scored automatically by the WS via its neural network
- ACT records were scored automatically by Actiware 5.0 software at medium wake threshold sensitivity (wake threshold value of 40 activity counts)
- 6 subjects contributed two nights of recordings and 4 subjects one night, resulting in 16 total records
- Inter-rater agreement was performed on summary statistics of sleep parameters on a 30-second epoch-by-epoch basis for agreement/disagreement of sleep/wake decisions.

Results:

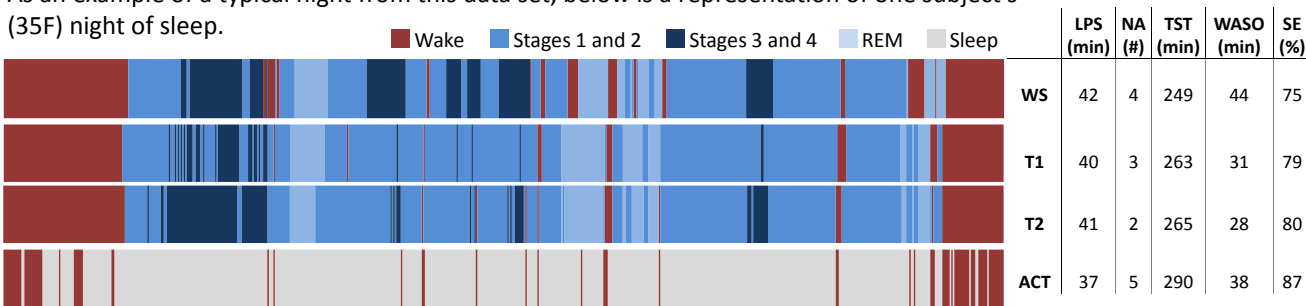
Mean sleep/wake measurements between the three systems appeared to be similar. The WS is designed to accurately detect wake periods that last for at least 2 minutes. Therefore, number of awakenings is reported as awakenings lasting at least 4 continuous epochs.

Sleep and Wake Summary Measures		WS	T1	T2	ACT
Latency to Persistent Sleep 10 continuous minutes	LPS (min \pm SEM)	31.8 \pm 16.1	33.0 \pm 16.5	36.4 \pm 16.3	34.7 \pm 15.8
Number of Awakenings Occurring after onset of persistent sleep and lasting at least 2 continuous minutes	NA (# \pm SEM)	2.6 \pm 0.7	2.2 \pm 0.4	2.2 \pm 0.4	3.3 \pm 0.6
Total Sleep Time	TST (min \pm SEM)	312.8 \pm 17.8	303.3 \pm 17.7	296.8 \pm 16.7	313.2 \pm 13.9
Wake After Sleep Onset	WASO (min \pm SEM)	41.7 \pm 13.4	27.8 \pm 3.7	47.1 \pm 8.5	48.5 \pm 9.7
Sleep Efficiency	SE (% \pm SEM)	86.7 \pm 3.4	84.5 \pm 4.0	82.6 \pm 3.6	86.4 \pm 2.4

Sensitivity and specificity to sleep were higher in the WS than in ACT when compared to PSG. Inter-rater agreement of sleep/wake between the WS and PSG was moderate-to-high, while agreement between ACT and PSG was moderate-to-low.

	Sleep Sensitivity	Sleep Specificity	Accuracy	Cohen's kappa
WS v T1	96.2%	72.9%	90.7%	0.63
WS v T2	95.9%	69.1%	88.4%	0.57
ACT v T1	92.8%	65.1%	84.8%	0.41
ACT v T2	93.5%	65.0%	84.6%	0.43

As an example of a typical night from this data set, below is a representation of one subject's (35F) night of sleep.



Conclusion:

The wireless system shows promise as an effective way to distinguish wake and sleep during the night and has potential as a cost-effective ambulatory system that can distinguish sleep and wake, while also providing sleep stage information over the course of nighttime recordings.

Support: This research was funded by Zeo, Inc, Newton, MA, USA.