Popular Wearables May Facilitate Affordable Long-term Reliable Actigraphy

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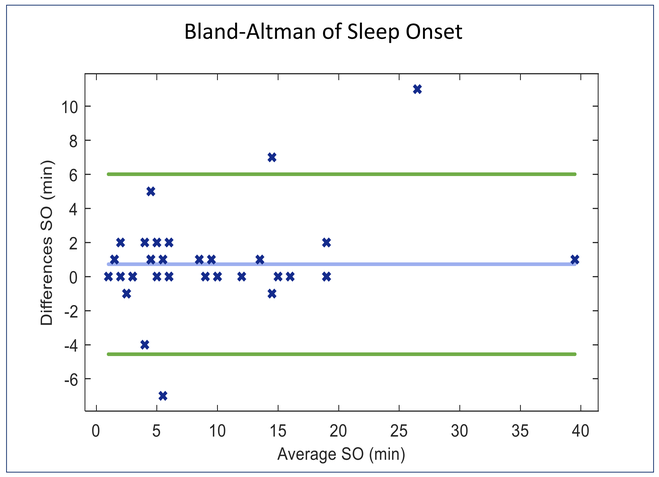
INTRODUCTION

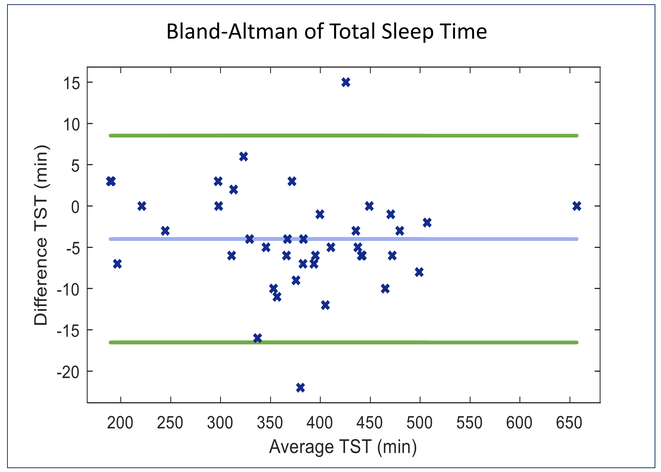
The rising availability of connected wearables with accelerometer sensing opens opportunities for multiple nights sleep monitoring in the natural sleep environment. We have developed an algorithm for sleep/wake classification using commercial wrist-worn devices that allow access to raw accelerometer data. Most activity devices offer also a sleep tracking feature, yet most do not provide validation. We aimed at validating our sleep monitoring algorithm, integrated with the device agnostic SleepRate mobile app.

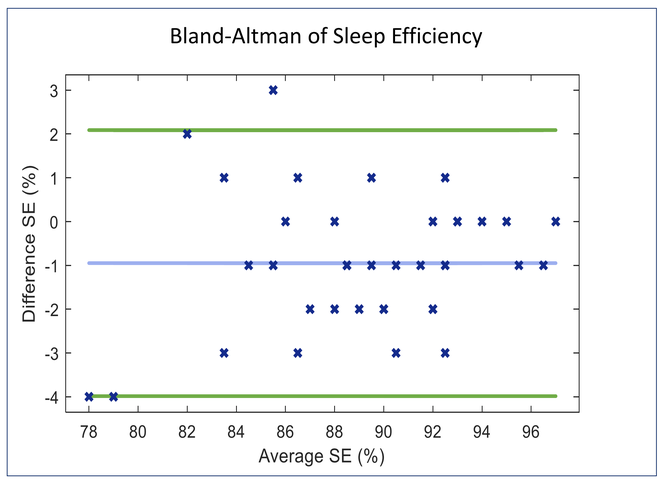
METHODS

We chose to validate the algorithm using one of the most popular wearables, the Apple Watch. The reference used was the medical actigraph system (Actiwatch Spectrum, Respironics).

1. Data from 50 nights recordings performed by 36 users served for training and testing the algorithm.
2. All users recorded simultaneously with both devices worn on their non-dominant wrist.
3. The candidate algorithm used the proportional integration method on the 3-axes accelerometer data.
4. The reference actigraphic data was scored using the Actiware software.
5. The resulting sleep/wake sequences, as well the sleep parameters from both systems were compared.







RESULTS

33,808 epochs were scored by both methods and were used for validation.

The epoch-by-epoch data analysis results showed:

- ✓ Agreement: 95.6%
- ✓ Sensitivity for wake: 83%
- ✓ Specificity: 97%
- ✓ Cohen's Kappa coefficient: 0.76

As for sleep parameters, on average, our algorithm:

- ✓ Underestimated total sleep time by 4.0 minutes (STD 6.2).
- ✓ Overestimated sleep latency by 0.73 minutes (STD 2.61).
- ✓ Underestimate sleep efficiency by 0.95% (STD 1.50%)

CONCLUSION

Our accelerometer-based algorithm provides sleep/wake classification during bed time recording with reliability comparable with that of medical actigraphy, and shares the same limitations. The same algorithm has been validated with some Android devices with the same accuracy, making our sleep monitoring device agnostic. The advantage is that accelerometer-based consumer wearable devices are owned by many, and may be continuously used to provide objective measures of sleep patterns when sleep evaluation and behavioral sleep therapy are implemented.