

Comparison of 10 Nights' Sleep Analysis between Actiwatch 2 and Vivosmart 4

For Researchers and Data Scientists

Abstract

In the previous two posts, we reverse-engineered the Actiwatch 2 algorithm for deriving sleep/wake patterns and sleep parameters from raw acceleration (ACC) data. This post applied the same algorithms to 10 nights of raw-ACC data obtained from Vivosmart 4 and compared the results with Actiwatch 2.

As described here, we found both the sleep/wake patterns and sleep parameters derived from Vivosmart 4 to be consistent with that of Actiwatch 2. The result suggests that an affordable, consumer wearable such as Vivosmart 4 can reproduce the results from a more expensive, medical-grade actigraphic device like Actiwatch 2.

1. Comparison of Sleep/Wake Detection and Sleep Parameters

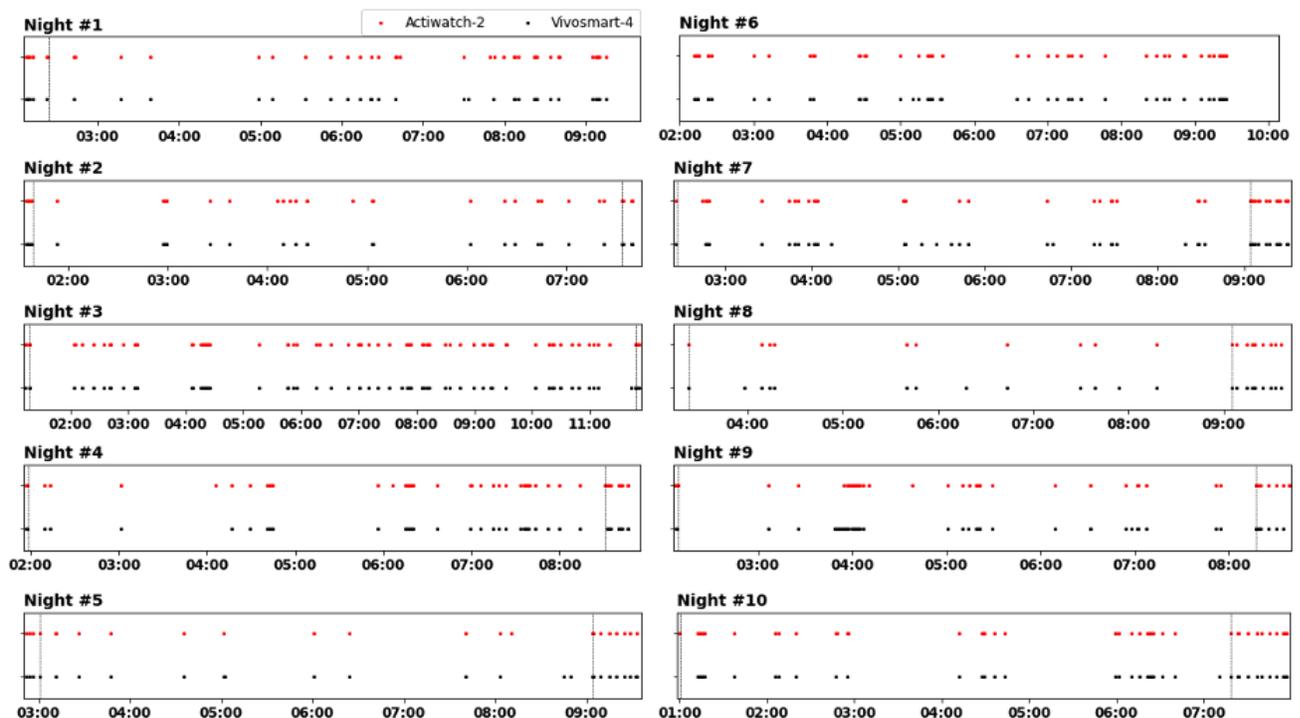


Figure 1. Sleep/Wake Patterns of 10 nights derived from Actiwatch 2 and Vivosmart 4.

Figure 1 illustrates the sleep/wake patterns of the 10 nights derived from Actiwatch 2 and Vivosmart 4 (the method was introduced [here](#)). The two vertical dashed lines in each subplot indicated the Actiwatch 2 scored sleep onset and offset. Table 1 lists the consistent and inconsistent results between Actiwatch 2 and Vivosmart 4. The number in each cell is the total minutes within sleep onset and offset in the 10 nights. Treating the result from Actiwatch 2 as a standard, the sensitivity (to detect sleep), specificity, and accuracy of Vivosmart 4 are near 1.00, 0.84, and 0.99, respectively.

Table 1. Confusion matrices of sleep/wake detection.

		Actiwatch 2		
		Sleep (min)	Wake (min)	
Vivosmart 4	Sleep	3942 (TP)	30 (FP)	Sensitivity = $TP / (TP+FN) = 0.994$
	Wake	23 (FN)	161 (TN)	Specificity = $TN / (TN+FP) = 0.84$ Accuracy = $(TP+TN) / (TP+TN+FP+FN) = 0.99$

Table 2 compares the differences in sleep parameters (introduced [here](#)) between Actiwatch 2 and Vivosmart 4. The two watches showed good consistency as the mean differences of most of the parameters is smaller than 5 mins.

Table 2. Differences in sleep parameters.

Sleep Parameter	Actiwatch 2	Vivosmart 4	Mean Absolute Difference
Time in Bed (min)	441.4 ± 78.0		-
O-O interval (min)	415.1 ± 86.9	415.4 ± 86.3	2.2 ± 3.6
Onset Latency (min)	6.1 ± 5.5	4.8 ± 3.9	1.3 ± 3.5
Wake after Sleep Onset (min)	19.1 ± 11.0	18.3 ± 9.4	2.6 ± 1.7
Total Sleep Time (min)	395.8 ± 77.0	397.0 ± 78.5	3.2 ± 3.4
Sleep Efficiency (%)	0.89 ± 0.03	0.90 ± 0.03	0.01 ± 0.01
# Awake	24.0 ± 10.9	24.4 ± 10.8	2.0 ± 1.7

2. Conclusion

We reverse-engineered the full algorithm utilized in the Actiwatch 2 to derive nighttime sleep/wake patterns and sleep parameters from the raw acceleration signal. Both the sleep/wake patterns and sleep parameters derived from Vivosmart 4 are consistent with that of Actiwatch 2. The result suggests that an affordable, consumer wearable such as Vivosmart 4 can reproduce the results from a more expensive, medical-grade actigraphic device.

3. Reference

[1] K. Y. Chen and D. R. Bassett, "[The technology of accelerometry-based activity monitors: current and future](#)," Med. Sci. Sports Exer., vol. 37, pp. S490–S500, Nov. 2005.

[2] CamNtech, "The MotionWatch 8 and MotionWare User Guide," Available at <http://www.medicoimpianti.it/files/The-MotionWatch-User-Guide.pdf>, 2018.

[3] Respirationics, "Instruction manual of Actiwatch Communication and Sleep Analysis Software. Instruction manual." Available at <https://johnawinegarden.files.wordpress.com/2015/03/actiwatchsoftware.pdf>, 2015