Kalpa Publications in Computing

Volume XXX, 2022, Pages 139–142

Proceedings of V XoveTIC Conference. XoveTIC 2022

Validation of the quality of sleep data generated by Xiaomi Mi Band 5

Estefanía Rivas[1], Diego Alvarez-Estevez[2], Patricia Concheiro-Moscoso[3], and Javier Pereira Loureiro[3]

[1] Universidade da Coruña (University of A Coruña), 15001, A Coruña, Spain
estefania.rv.24@gmail.com

[2] CITIC, Universidade da Coruña (University of A Coruña), Elviña Campus, 15071 A Coruña, Spain
diego.alvareze@udc.es,

[3] CITIC, TALIONIS group, Elviña Campus, Universidade da Coruña (University of A Coruña), 15071 A Coruña, Spain
patricia.concheiro@udc.es, javier.pereira@udc.es

Abstract

The wristbands are very popular among the population due to factors such as their low cost, ease of use, designs and the feedback they provide to the consumer. These wearables track activity, heart rate and sleep-wake patterns. However, few studies have analysed the reliability of the data collected by these activity devices.

The validation of sleep data should be carried out by comparing it with Polysomnography (PSG), which is the standard test for measuring sleep parameters in the clinical setting. Thus, the aim of this project is the validation of the data quality of the Xiaomi Mi Band 5 wristband, when compared with the data by the hospital sleep unit devices during the performance of the polysomnography test.

In order to achieve this objective, an Epoch by Epoch (EBE) analysis will be performed to analyse how similar the results obtained by the two methods are. This analysis will use data from 45 people who underwent a PSG test and wore a Xiaomi Mi Band 5 bracelet for one night in a sleep unit of a hospital in A Coruña. For this analysis, raw data from the PSG device and data from the Xiaomi Mi Band 5 wristband were used. In addition, different sleep variables were determined with the data extracted from both devices and following the guidelines of the American Academy of Sleep Medicine (AASM) manual.

1 Introduction

In recent years, activity wristbands have become a product with a high market acceptance. They offer motion detection of sleep-wake patterns by measuring heart rate. For this reason, the possibility of using them as an alternative to techniques such as polysomnography (PSG) has been studied. This method is performed in sleep units, which are specialised areas in the diagnosis and treatment of different types of sleep disorders. This fact, together with its cost, handling, application time and the fact that it is an intrusive instrument, are some of the reasons why other alternatives are being sought.

Existing studies on this subject are scarce and all of them focus on comparing the data obtained with these devices with those obtained with PSG or actigraphy. The results obtained [3, 2, 1] show an estimation of sleep-wake states that is not significant and has limitations.

The aim of this work is to make a comparison between the data obtained by the PSG and the Xiaomi Mi Band 5. For this purpose, different sleep parameters are calculated and a Epoch by Epoch (EBE) analysis will be performed in order to analyse how similar the results obtained by the two methods are.

2 Methodology

Two datasets are used to carry out the objective presented. The first one is the PSG data extracted from 45 individuals from the sleep unit. On the other hand, the second set is made up of the data collected by the wristband from the same 45 individuals.

Three factors should be taken into account before the procedure is carried out. The first is the difference in the start of recording between the two devices. In the case of the PSG, it is the clinician who initiates the recording, while the wristband does not start recording until it detects one of the sleep phases. Besides, the PSG detects five phases of sleep (Wake, N1 sleep, N2 sleep, N3 sleep and REM sleep), while the Xiaomi Mi Band 5 is only able to differentiate between four (Wake, Light sleep, Deep sleep and REM sleep), where the first one includes stages N1 and N2, and the second N3. Finally, the PSG records every 30 seconds, i.e. the duration of each epoch is always 30 seconds. However, Xiaomi records the start and end time of each state throughout the sleep period, so the duration of each annotation is variable based on periods lasting one minute.

2.1 EDF$^+$hospital

To recreated the report generated by the equipment, an European Data Format (EDF) file is created using the Python PyEDFlib library [4]. The first step is to extract four dates from the report generated in the hospital: start, lights off, lights on and end. Then, three parameters must be defined for each annotation: onset (time in seconds at which the annotation starts with respect to the startdatetime) duration (time in seconds that the annotation lasted) and description (name given to each annotation).

Subsequently, the parameters sleep onset (transition period from waking to sleeping), sleep latency (time from lights out to the first epoch of any sleep phase), time in bed (TIB, total time from lights off to lights on), total sleep time (TST, sleep time between lights off and lights on markers), sleep efficiency (fraction between TST and TIB), duration (total sum of the duration time of the annotations of each phase) and latency (difference between first annotation with first label of the phase of interest) of the different sleep phases are calculated.

2.2 EDF$^+$Xiaomi Mi Smart Band 5

Since the ultimate aim of this work is to make a comparison between the two methods, the datetimes defined in the case of the PSG must be transferred to create the EDF$^+$ file with the Xiaomi data. Then the same methodology is followed as in the previous case.

2.3 Validation analysis

An Epoch by Epoch (EBE) analysis is performed to calculate the sensitivity, specificity, as well as the degree of agreement between the two devices in the identification of sleep phases. Two different types of EBE are performed. In the first one, an analysis is carried out by grouping the sleep phases into awake (W) or asleep (S). In the second, they are grouped into awake, Light sleep (N1+N2), Deep sleep (N3) and REM. Then, the two sets of data are evaluated using accuracy and kappa score. In addition, the total time awake and asleep is calculated, as well as the time that is not being taken into account in the validation.

Based on the fact that Xiaomi will never start with an awake phase, a new approach is tested in which we assume that the time where are no records the subject is always awake. Again, the two types of clustering are used and the accuracy and kappa metrics are calculated.

3 Results and Discussion

With the developed methodology it is possible to recreate the hypnogram and the parameters shown in the PSG report.

The final results of the study are shown in Table 1. It shows the data obtained for accuracy, kappa, non-validated time and the non-validated ratio considering the two cases: when there is no record in Xiaomi the subject is awake (1) or considering this time as non-recorded (2). And for each of the two cases, the information is grouped in W/S (a) or W/Light sleep (N1+N2)/Deep sleep (N3)/REM (b). It can be observed that the mean kappa score is between 0 and 0.20, indicating that the degree of agreement is not significant. Furthermore, with the second strategy this measure is increased, which is to be expected given an average of 10.58% was not being evaluated. On the other hand, the large difference between the value of accuracy and kappa reflects how unreliable the calculation of accuracy is in these cases.

Strategy	Accuracy	Kappa	Non-validated time	Non-validated ratio
1-a	0.809	0.032	2778	10.58
1-b	0.780	0.223		
2-a	0.431	0.065	2778	10.58
2-b	0.442	0.122		

Table 1: Results obtained by following both strategies and grouping the sleep phases in two different ways.

4 Conclusions

The methodology developed has enabled us to reconstruct the hypnogram from the data obtained by polysomnography. In addition, the hypnogram has been constructed from scratch from the data collected by the wristband.

An Epoch by Epoch validation of the quality of the data collected by the Xiaomi Mi Band 5 bracelet was then performed. The results show that the Xiaomi Mi Band 5 device has limitations in the estimation of sleep-wake states.

References

[1] Rachel Danzig, Mengxi Wang, Amit Shah, and Lynn Marie Trotti. The wrist is not the brain: Estimation of sleep by clinical and consumer wearable actigraphy devices is impacted by multiple patient-and device-specific factors. *Journal of sleep research*, 29(1):e12926, 2020.

[2] Massimiliano de Zambotti, Aimee Goldstone, Stephanie Claudatos, Ian M Colrain, and Fiona C Baker. A validation study of fitbit charge 2™ compared with polysomnography in adults. *Chronobiology international*, 35(4):465–476, 2018.

[3] Piyumi Kahawage, Ria Jumabhoy, Kellie Hamill, Massimiliano de Zambotti, and Sean PA Drummond. Validity, potential clinical utility, and comparison of consumer and research-grade activity trackers in insomnia disorder i: In-lab validation against polysomnography. *Journal of sleep research*, 29(1):e12931, 2020.

[4] Holger Nahrstaedt, Simon Kern, LucaCerina, Stefan Appelhoff, David T.H. Kao, Craig Franklin, Shannon Clarke, Jukka Zitting, David Ojeda, Chadwick Boulay, Ogi Moore, and Daniil Kosachev. holgern/pyedflib: v0.1.23, February 2020.