WITHINGS

SLEEP APNEA
#1 WORLDWIDE*
DETECTION

THE TECH BEHIND

Sleep Analyzer

Under-mattress sleep tracker

Sleep cycles: deep, light and REM
Sleep Score
Continuous heart rate tracking
Snore detection
Sleep apnea detection

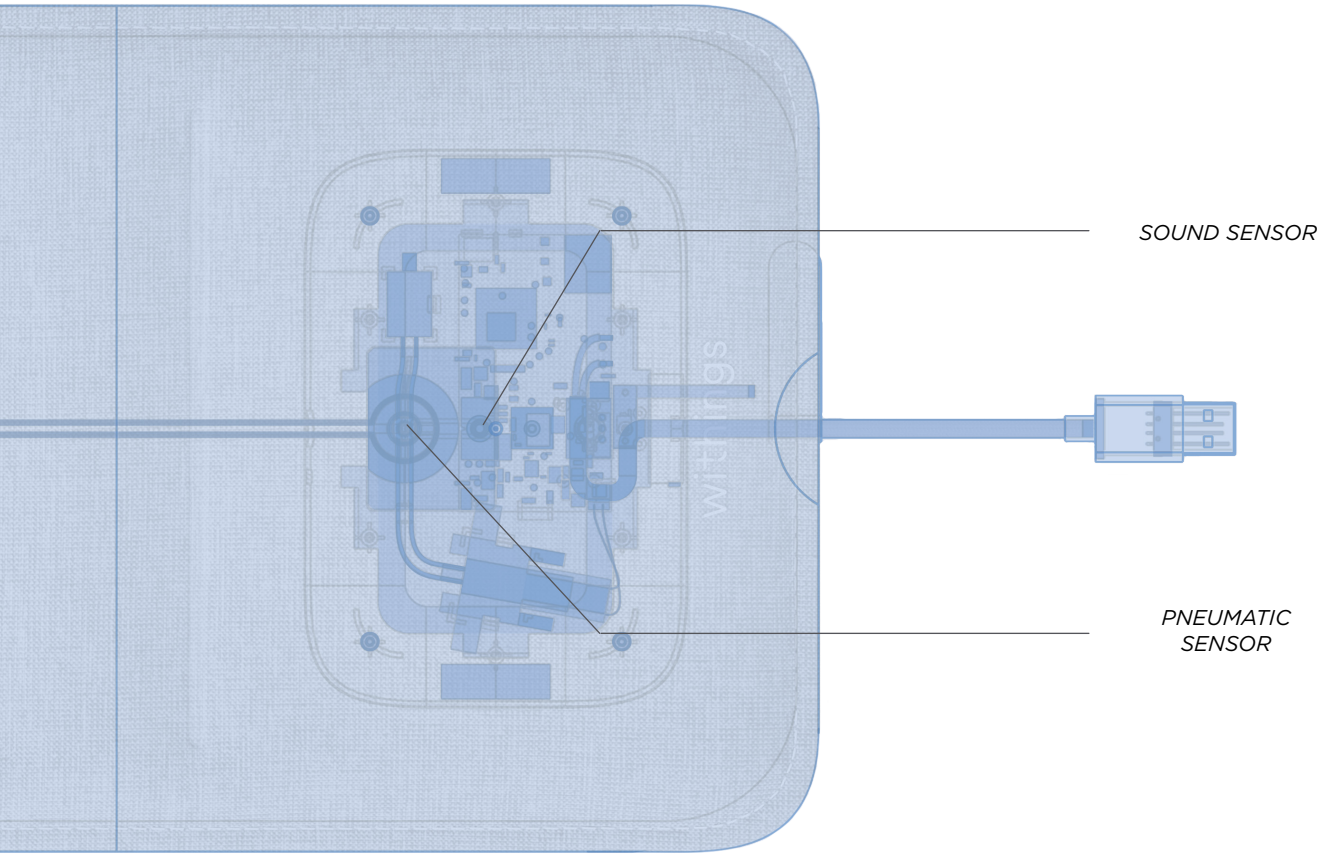
CLINICALLY VALIDATED

Dive into the tech behind Sleep Analyzer

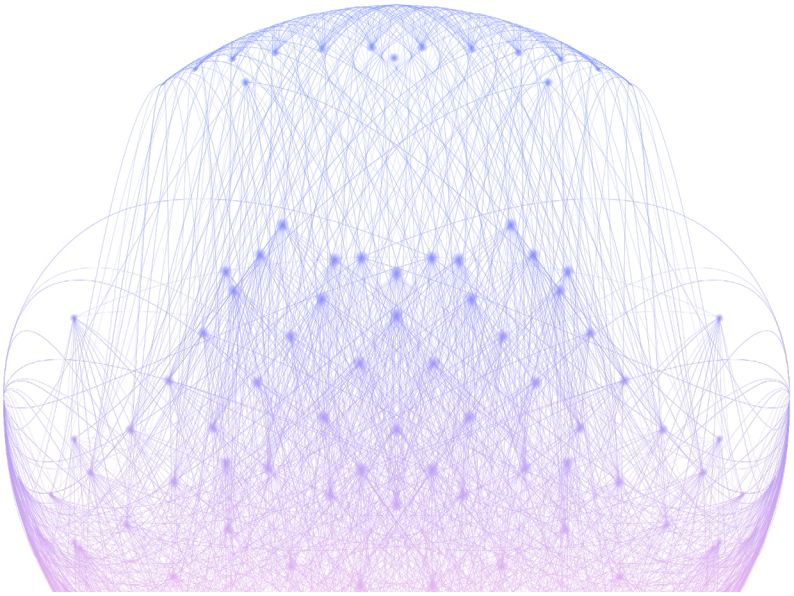
Medical sleep analysis involves wearing multiple electrophysiological sensors during the night. Therefore, it can be both costly and uncomfortable. Also, because of the amount of time required for analysis, your results may not be instantly available, and the process can't be easily reproduced from one night to another.

Withings Sleep Analyzer is a **sleep sensor placed under the mattress** at chest level with a one-time setup. It contains two sensors: a sound sensor that identifies **audio signals specific to snoring & cessation of breathing episodes**, and a pneumatic sensor that measures your **respiratory rate, heart beats via ballistocardiography, and body movements** across the mattress.

Thus, Withings Sleep Analyzer is a **unique and innovative combination of two powerful sensors**, in the sense that 1) they complement each other in an unusual way to track multiple metrics during sleep, and 2) because of their placement, they can accurately sense human activity from under the mattress, as well as sound.



Withings has developed **strong proprietary algorithms**, proven by ten years of use and improvements, that unleash the power of Sleep Analyzer and its sensors.



EXCLUSIVE
SNORING ALGORITHM

EXCLUSIVE
SLEEP ANALYSIS ALGORITHM

EXCLUSIVE
HEART RATE ALGORITHM

EXCLUSIVE
SLEEP APNEA ALGORITHM

The data analyzed with those algorithms provides sleep analysis that is **consistent overall with polysomnography recordings**, the gold standard for sleep measurement, in terms of sleep duration and sleep-stage recognition.

The development of Sleep Analyzer

Sleep Analyzer has been **developed and calibrated in collaboration with sleep experts** from Hôpital Béclère in Paris, France to provide the most in-depth and accurate insights.

Withings has **registered this product for 6 patents**:

3 for the device and system for sleep tracking, and 3 for embedded intelligence: one for pressure drifting, one for heart activity tracking, and one for sleep-apnea detection.

How it works

SLEEP CYCLES: DEEP, LIGHT AND REM

Sleep Analyzer senses your body's various **mechanical variations, including heart activity, respiration rate and body movement tracking**. By tracking these physiological parameters, Sleep Analyzer can assess whether you're in your bed and which sleep stage you are in.

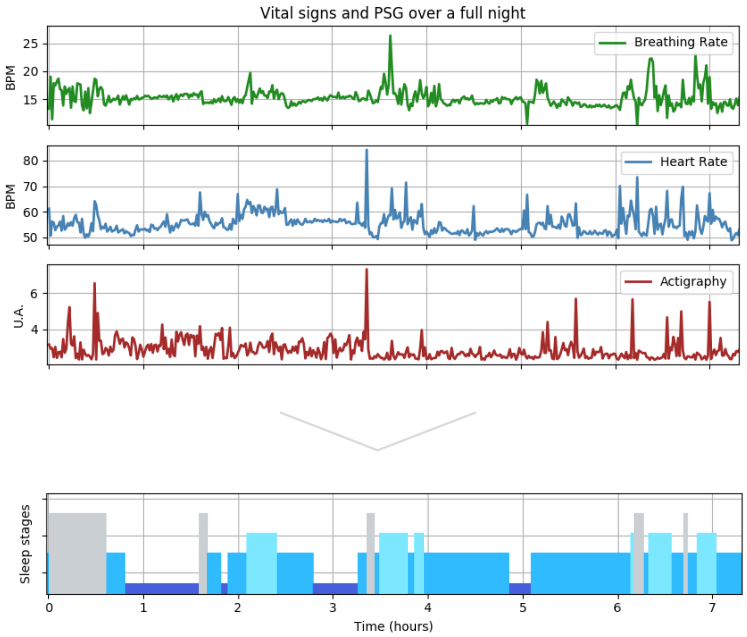
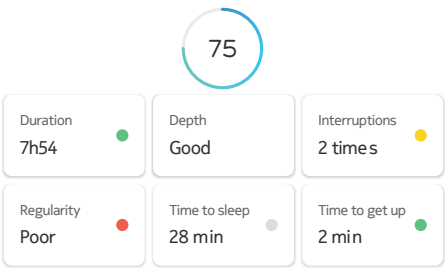


Fig. 1: Sleep stage assessment through breathing rate, heart rate, and actigraphy measurements

SLEEP SCORE

In addition to sleep stages, Sleep Analyzer provides a Sleep Score with 6 parameters so you can see how restful the night was.

The Sleep Score has been developed with sleep physicians and implemented by the Withings team, which created **a specific weighting** that reflects the importance of each item for the human body during sleep from a physiological point of view. The most important parameter is sleep duration; this accounts for more than 50% of the Sleep Score. The second most important parameter is sleep depth. The next important parameters are interruptions, regularity, time to fall asleep, and time to wake up.



CONTINUOUS HEART RATE TRACKING

Each time your heart beats, **it propels a mechanical wave through your body**. This wave is **measured through the mattress at high frequency by the pneumatic sensor of Withings Sleep Analyzer**. This technique, called ballistocardiography (BCG), has already proven its effectiveness in the measurement of cardiac activity in clinical studies.

Heart rate tracking with Withings Sleep Analyzer is extremely precise, as it is **continuously measured** during the entire night and measured at high frequency, unlike a sleep tracker worn on the wrist. Indeed, the measurement of cardiac activity is sampled at 250 Hz to deduce the number of beats per minute.

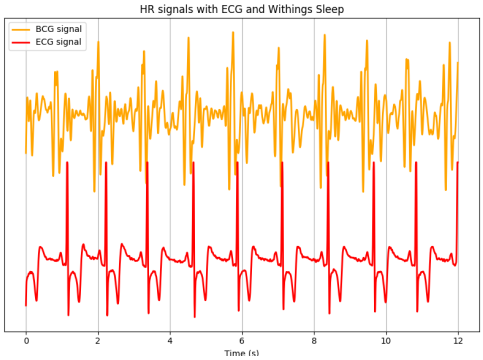


Fig. 2: Heart activity as recorded by an ECG (in red) and the same activity recorded by Sleep through BCG (in yellow)

SNORE DETECTION

Sleep Analyzer **computes the sound sensor signal thanks to its snoring algorithm**, which is trained against a dataset of low to heavy snorers. A wide variety of unwanted noises has been included in this dataset: subway noises, partner snoring, washing machine noises, cell phone vibration, and TV shows.

And by cross-referencing the breathing rate and audio signals to target snoring patterns, Withings Sleep Analyzer can **distinguish your snoring patterns from environmental noises and your partner's snoring patterns.**

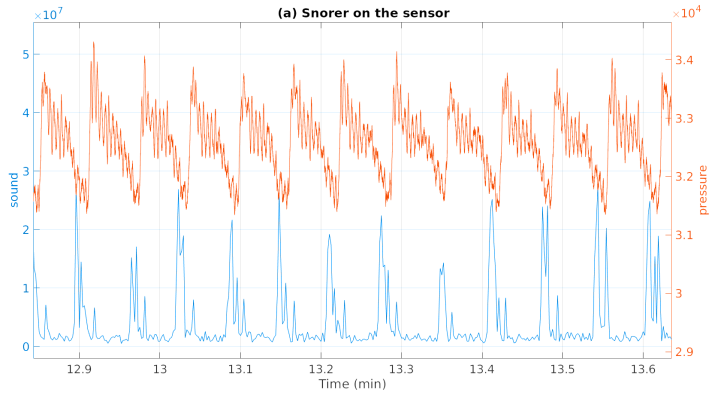


Fig. 3: Pressure signal where the breathing patterns (slow variations) and heart rate (quick variations) can be read (in red) and audio signal with highly probable snoring patterns (in blue) before crossing with breathing patterns.

SLEEP APNEA DETECTION

In the established tools for medical diagnosis of sleep apnea (including polygraph, also known as PSG or PG), some physiological parameters are used, such as the airflow in the upper airways, which is measured via tracheal sensor (a microphone attached to the neck); blood oxygen saturation (SpO2 measured on a finger); and thoracic activity (measured via an abdominal belt).

Sleep Analyzer tracks some of these precious parameters for sleep apnea detection, including **snoring and thoracic activity**. In addition, Sleep Analyzer **innovates by using physiological parameters, such as heart activity through ballistocardiography**, to help detect sleep apnea.

A total of 6 features are used as inputs to feed the algorithm, which is based on the cutting-edge technology of **a convolutional neural network**. This algorithm is powerful, as it was trained and validated on a very large cohort of apneic patients at Hôpital Béclère.

These features enable Sleep Analyzer to estimate the average number of sleep apnea episodes per hour of sleep and to detect the severity of sleep apnea for a given user/night.

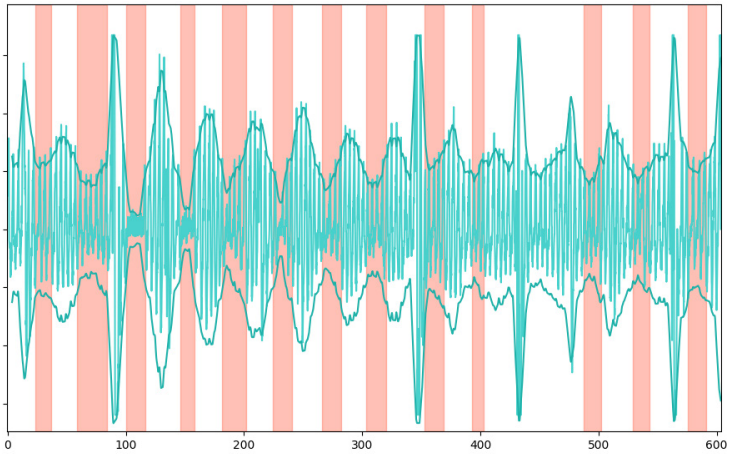


Fig 4: The pink bars indicate the apnea episodes identified via PSG by Béclère Hospital. The green curve represents the variations of the Sleep Analyzer pressure sensor. The pressure drops coincide with the apnea episodes.

Putting it all together

The Withings Sleep Analyzer employs a unique combination of highly-accurate pneumatic and sound sensors. When these sensors are paired with a clinically developed algorithm, they can help detect sleep apnea, and give anyone an in-depth analysis of their nights, so they can improve their days.