

# Simple new way to analyze sleep disorders

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Sleep is such an essential part of human existence that we spend about a third of our lives doing it -- some more successfully than others. Sleep disorders afflict some 50-70 million people in the United States and are a major cause of disease and injury. People who suffer from disturbed sleep have an increased risk of heart attack, stroke, hypertension, obesity, depression, and accidents. Nearly a fifth of all serious car crashes, in fact, are linked to sleeplessness.

Diagnosing [sleep disorders](#) is not necessarily easy. In standard "sleep studies," people spend one or more nights at hospitals or other inpatient centers, sleeping while sensors and electrodes attached to the head and torso record breathing, brain waves, heart rate, and other vital signs.

Now, a group of scientists in Israel and Germany has discovered a simple new way to monitor sleep and potentially diagnose sleep disorders just by recording someone's heart rate. Their method relies on using a mathematical technique to analyze these recordings and tease out information related to the synchronization between [heartbeat](#) and breathing, which might be a measure of fitness of the cardio-respiratory system.

Their work may one day help clinicians more easily diagnose sleep disorders and determine optimal treatments for people with congestive [heart failure](#). Athletes might also be able analyze their own recordings to optimize workouts.

Conducted by researchers at Technische Universität Ilmenau in

Germany, Bar-Ilan University in Ramat Gan, Israel, Martin-Luther-Universität Halle-Wittenberg in Germany, and Schlafmedizinisches Zentrum der Charité Berlin, the work appears in a special focus issue of the journal *Chaos*, which is published by the American Institute of Physics (AIP). The special issue is focused on nonlinear dynamics in cognitive and neural systems. It asks how chaos affects certain brain areas and presents interdisciplinary approaches to various problems in neuroscience -- including sleep disorders.

Monitoring the heartbeat provides information about breathing because the two physiological processes are weakly coupled. During inhalation, the heart beats faster. During exhalation, the heart slows down. These effects are seen during sleep as well. Moreover, the heart rate and breathing rate also change across certain stages of sleep. They are faster and fluctuate more during rapid eye movement (REM) sleep than they do during deep sleep, for instance.

In their new study, the Israeli and German scientists showed that the synchronization between the heartbeat and breathing pattern is significantly enhanced during certain stages of sleep. By mathematically analyzing someone's heart rate throughout the night, they could gain information on that person's breathing and sleep stage.

They looked at data from the European project SIESTA, which keeps a database of sleep data recorded in seven countries from 295 people -- about half of whom have sleep disorders. Subjects of this study spent two nights in sleep laboratories, slumbering while electrodes connected to their heads and torsos monitored things like brain and muscle activity, [heart rate](#), and eye movement. This collection of physiological data is what normally enables doctors to reconstruct the phases of sleep and diagnose sleep disorders.

The Israeli and German scientists analyzed just the heart data for the 150

people in the SIESTA study who have no known sleep disorders. They then used the heartbeats to reconstruct the breathing patterns, and they showed that these reconstructions accurately reflect the actual recorded breathing data collected in sleep labs. Moreover, looking at the synchronization between heartbeat and breathing, the group could show that there is a significant relationship between sleep stages and cardio-respiratory synchronization patterns, i.e., heartbeat and [breathing](#) mostly synchronize during non-REM sleep (light and deep sleep), and cardio-respiratory synchronization is almost absent during REM sleep.

Next they plan to extend their study to people with [sleep](#) disorders to determine whether their technique can accurately diagnose these disorders. Analyzing the heartbeat using their technique may also reveal information about cardiorespiratory capacity, which may lead to diagnostic markers of cardiac diseases and ways to determine optimal treatments for people with congestive heart failure. Monitoring cardiorespiratory capacity may also help athletes optimize workout routines.

**More information:** The article "Automated synchrogram analysis applied to heartbeat and reconstructed respiration," by C. Hamann et al. appears in Chaos 19, 015106 (2009). [chaos.aip.org](http://chaos.aip.org)

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