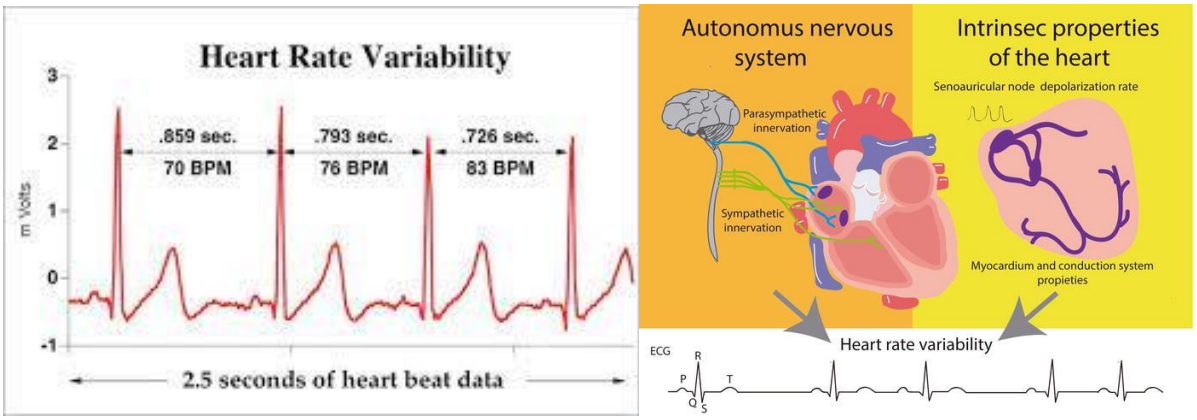
HRV and its applications

What is HRV?

Heart rate variability is where the amount of time between your heartbeats fluctuates slightly. Even though these fluctuations are undetectable except with specialized devices, they can still indicate current or future health problems, including heart conditions and mental health issues like anxiety and depression.

A strong healthy heart will speed up and slow down constantly to address environmental changes and stressors as they appear. Consistency is not something to strive for when it comes to the heart. Healthy hearts should have beat-to-beat variability and not consistently beat at the same tempo. This variation between heartbeats is called Heart Rate Variability (HRV).

HRV is calculated by looking at the fluctuations between individual heartbeats. The time between each consecutive heartbeat has many names such as R-R interval or inter-beat-interval (BBI or IBI) and is calculated in milliseconds. That data is then used to calculate the variability that exists in the person's heartbeat. Using HRV, an individual's Autonomic Nervous System (ANS) (سیستم عصبی خودمختار) can be analyzed.



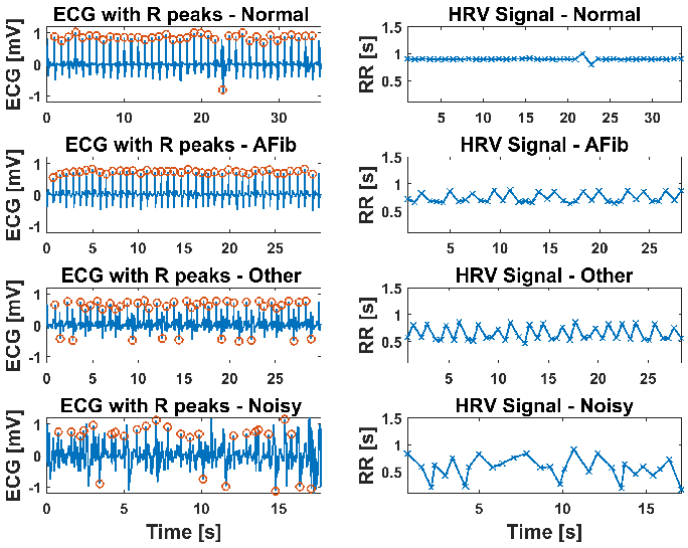
Why is HRV important?

Tracking HRV over time and correlating data segments with specific activities or life events can provide unique insights into the person's physical fitness level, overall health, or mental health. Looking at an individual's HRV trends can also help identify whether lifestyle changes, medications, or other medical interventions are working as intended.

Measuring HRV:

- ✓ Time domain (SDRR, RMSSD, pnn 50)
- ✓ Frequency domain (VLF, LF, HF, LF/HF ratio)
- ✓ Nonlinear domain (MSE, DFA a1, DFA a2)

Methods including ECG (EKG) can be used to calculate HRV. These methods would involve using a portable Holter Monitor, electrodes stuck to the chest, or chest strap heart monitors. These methods record all the movements of the heart and map out the waves of movement, otherwise knowns as the QRS complex. The largest energy wave in the QRS complex is called the R wave and it is using the time interval between R waves that IBI is calculated.



Applications of HRV in research:

An individual's HRV is a great indicator of their autonomic activity. Various physical and mental conditions affect the Autonomic Nervous System including autonomic neuropathies like diabetic neuropathy, depression, PTSD, anxiety, and cardiac health. HRV data will help indicate the level of stress or the seriousness of various health conditions by showing the body's ability to cope. This data can then be used to quantify overall health and identify if further interventions are needed to address specific pathological conditions such as cardiac disease or depression.

A normal HRV:

A normal HRV for adults can range anywhere from below 20 to over 200 milliseconds. A consistent baseline score of 70 or higher is associated with health;

whereas levels between 50 and 70 are compromised health and diseases; whereas a regular HRV below 50 puts the person at risk for catastrophic illness and even death.

What does high HRV mean?

When you have high heart rate variability, it means that your body is responsive to both sets of inputs (parasympathetic and sympathetic). This is a sign that your nervous system is balanced, and that your body is very capable of adapting to its environment and performing at its best. Higher resting heart rates happens because when your heart is beating faster, there's less time between beats, reducing the opportunity for variability. This is often the case with conditions like diabetes, high blood pressure, heart arrhythmia, asthma, anxiety and depression.

Can HRV detect heart problems?

Heart rate variability (HRV) values have been shown to be low in patients with CAD, and low HRV has been shown to be an independent predictor of cardiovascular mortality and sudden cardiac death.

Can heart rate variability detect arrhythmia?

Heart rate variability is a normal occurrence, and it isn't an arrhythmia on its own. The normal beating of your heart is called "sinus rhythm." When your heart is beating normally but the variability between heartbeats is greater than 0.12 seconds, this is called "sinus arrhythmia." Heart rate variability can sometimes meet the criteria for sinus arrhythmia.

Parasympathetic vs sympathetic branches and heart rate variability:

- **Sympathetic:** This is where your "fight-or-flight" response comes from. It manages increases in heart rate and blood pressure in emergency situations.
- **Parasympathetic:** This helps balance out the sympathetic nervous system and controls the natural relaxation response, especially after you've been in fight-or-flight mode. It controls slowing your heart rate and blood pressure, among other things, especially when you're taking it easy.

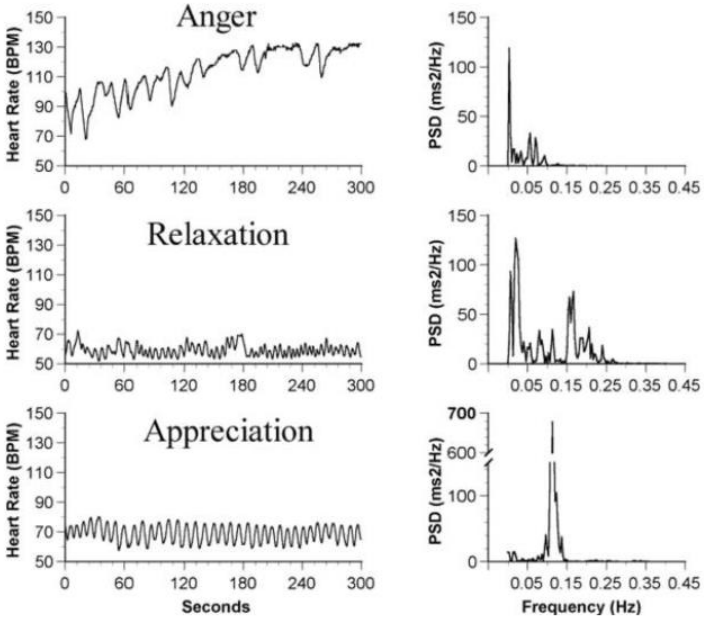
If you think you're in danger, you get scared or startled, or if you're anxious about something, your sympathetic nervous system kicks in and starts the fight-or-flight response. Your body releases adrenaline so you can react faster. Your heart rate goes up, just in case your muscles need more blood and oxygen because of physical activity.

Once the situation that put you into fight-or-flight mode is over, your parasympathetic nervous system takes the lead. It tells your heart rate to slow back down and lowers your blood pressure. It also tells various systems of your body to relax or go back to how they normally work.

High Frequency (HF) from 0.15 Hz to 0.40 Hz reflects the activity of the parasympathetic system and the vagus nerve.

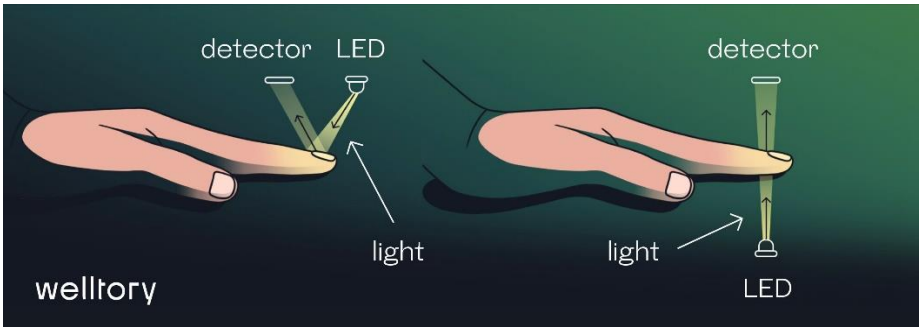
Low Frequency (LF) from 0.04 Hz to 0.15 Hz reflects sympathetic activity.

Very Low Frequency (VLF) from 0.003 Hz to 0.04 Hz reflects a host of factors, including not only the sympathetic nervous system, but also input from chemoreceptors, thermoreceptors, the reninangiotensin system and others



Measure HRV With PPG and Pulse Oximetry Devices:

When your heart beats, blood flows in and out of the capillaries in your finger. These changes in blood volumes make the tissue in your finger change color. During a measurement, the flash illuminates the tissue in your finger, the camera takes a video of the changes in blood volumes, and the result is a short clip of your heartbeat. PPG sensors measure the amount of infrared light absorbed or reflected by blood caused by pressure changes in blood vessels throughout the cardiac cycle. There are two types of functioning principles for photoplethysmography sensors: the transmission or reflection of light through or by a certain part of the body.



Research shows that measurements taken with a smartphone camera are just as accurate as those taken with heart rate monitors. Welltory's team ran their very own study, in which they showed that Welltory's PPG-based phone camera measurements are equal to measurements taken with Polar chest straps, which are ECG-accurate.)

Chest straps:

Most chest straps are made of a belt-like elastic band that goes around your chest, a tiny electrode pad, and a transmitter. These heart-rate monitors use electrocardiography to record the electrical activity of your heart. The transmitter can consistently send heart-rate data to your mobile device via Bluetooth, which acts as the receiver.

https://www.labfront.com/article/hrv-in-research

https://welltory.com/heart-rate-variability-gadgets/

Wavelet Transform

Wavelet transform uses the variable size of windows with a wavelet function. Wavelet analysis is usually applied in two ways, Continuous Wavelet Transform (CWT) and Discrete Wavelet Transform (DWT). CWT uses a wavelet function $\psi(t)$ and produces a scalogram, similar to a spectrogram for time-frequency analysis.