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Anjugramam - Kanyakumari Main Road, Palkulam, Variyoor P.O. - 629 401, Kanyakumari District.

1.2 Heart rate Monitor and Holter Monitor:

1.2.1 What are Heart rate monitors?

Heart rate monitors are devices designed to measure and display your heart rate in beats per minute (BPM) in real-time. These devices are commonly used in fitness, healthcare, and sports to monitor cardiovascular performance and overall heart health.

1.2.2 Why do people use heart rate monitors?

Heart rate monitors are very popular features in wearable devices like smartwatches and fitness trackers. Many of these devices also connect wirelessly to smartphones and computers. That allows users easy access to review their heart rate data. Heart rate monitors see common use for the following purposes:

- ❒ Tracking heart rate during exercise.
- ❒ Monitoring stress and activity levels during the day.
- ❒ Tracking sleep quality at night.
- ❒ Monitoring your vital signs at home, especially if you have certain health conditions or concerns.

1.2.3 How to Measure Your Resting Heart Rate:

- ❒ If you want to know your resting heart rate, it's best to check it as soon as you wake up in the morning.
- ❒ However, if your alarm clock jolted you awake, your heart may race for a few moments. If so, give it a few minutes to slow down.
- ❒ Its best to lie down while checking your RHR.
- ❒ Start by placing two fingers on your pulse at your neck or wrist.
- ❒ Count each heartbeat for 60 seconds. This is a better method to get the most accurate RHR.
- ❒ If you feel too sleepy to count all the way, you can count the beats for just 30 seconds

and then multiply your count by 2.

- You can even count for 6 seconds and then multiply by 10. This is an easier method but has a larger potential for error.

Resting heart rate chart

Resting heart rate chart for men							
By Age	Heartbeats Per Minute						
	Athlete	Excellent	Good	Above Average	Average	Below Average	Poor
18-25	49-55	56-61	62-65	66-69	70-73	74-81	82+
26-35	49-54	55-61	62-65	66-70	71-74	75-81	82+
36-45	50-56	57-62	63-66	67-70	71-75	76-82	83+
46-55	50-57	58-63	64-67	68-71	72-76	77-83	84+
56-65	51-56	57-61	62-67	68-71	72-75	76-81	82+
65+	50-55	56-61	62-65	66-69	70-73	74-79	80+

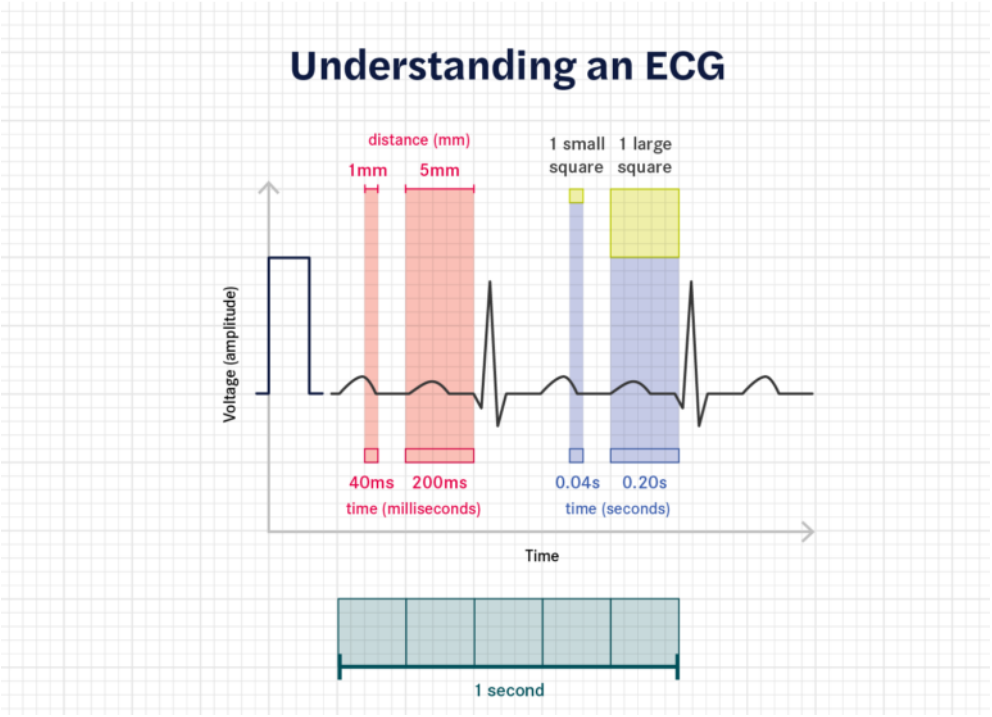
Resting heart rate chart for women							
By Age	Heartbeats Per Minute						
	Athlete	Excellent	Good	Above Average	Average	Below Average	Poor
18-25	49-55	56-61	62-65	66-69	70-73	74-81	82+
26-35	54-59	60-64	65-68	69-72	73-76	77-82	83+
36-45	54-59	60-64	65-69	70-73	74-78	79-84	85+
46-55	54-60	61-65	66-69	70-73	74-77	78-83	84+
56-65	54-59	60-64	65-68	69-73	74-77	78-83	84+
65+	54-59	60-64	65-68	69-72	73-76	77-84	84+

Bel Marra Health

1.2.4. Different types of Heart Rate Monitor:

There's usually no difference between heart rate and pulse rate (or the difference is very small). However, certain health conditions, medications or circumstances can make the pulse in the arms harder to detect. The term "heart rate monitor" refers to devices that can detect either heart rate or pulse rate. These devices use two different approaches:

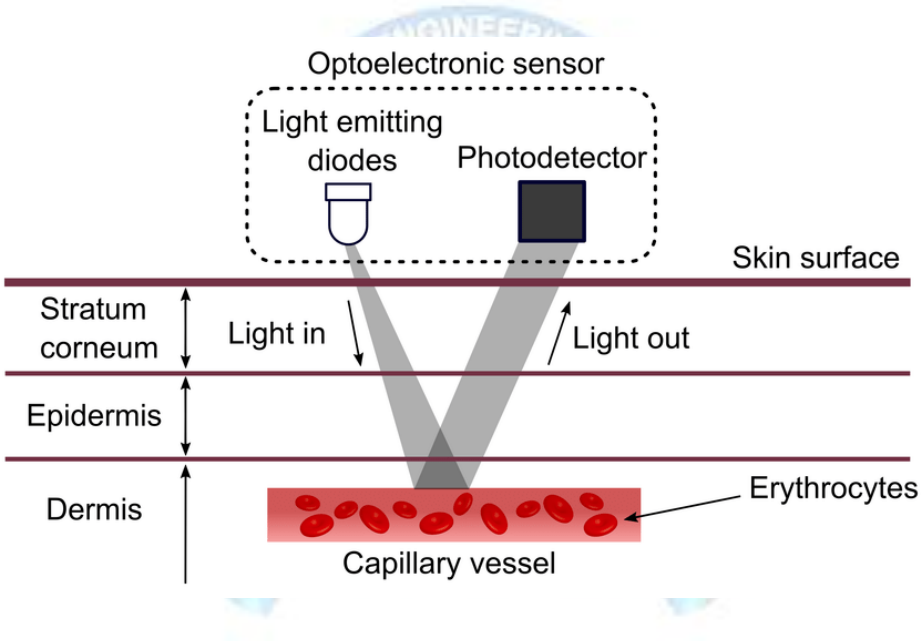
(a) **Electrical (electrocardiography)**: Your heart generates a small electrical current with every heartbeat. Heart rate monitors with electrical detection capabilities can detect and track that current.



Five large squares, when set to standard measurement, depict 1 second. One large square represents 0.2 seconds and a small square is equal to 0.04 seconds.

- 0.04 seconds x 5 small boxes = 0.2 seconds
- 0.2 seconds x 5 big boxes = 1 second

(b) **Optical (photoplethysmography):** These devices use infrared light to see the expansion of your arteries as your heart pumps blood through them. These devices track your pulse rate, and some can also estimate the oxygen levels in your blood.



❒ Photoplethysmography sensors measure the amount of infrared light absorbed or reflected by blood. Volume changes are caused by pressure changes in blood vessels, which occur throughout the cardiac cycle.

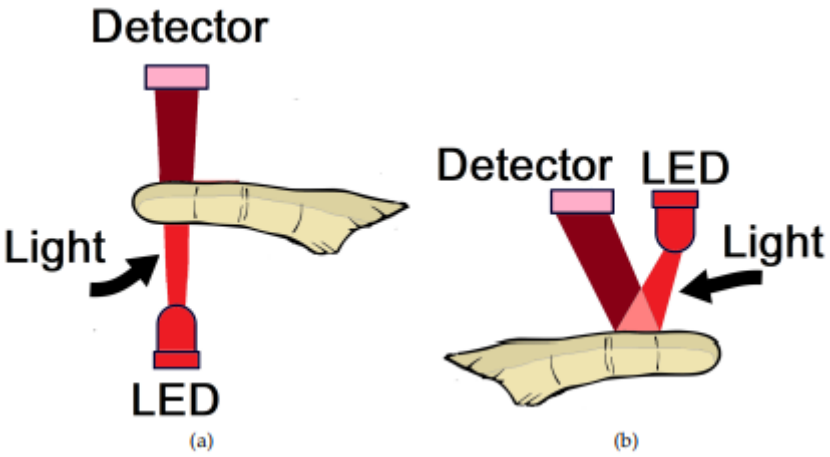


Figure 3. Representation of the operation of photoplethysmography sensors for finger application, by transmission (a) and by reflection (b).

- With a PPG sensor in transmission mode, the LED light passes through absorbent substances, such as the skin pigmentation, bone and arterial and venous blood, and is then received by the detector and quantified by filters and converters.
- In contrast, a PPG sensor in reflection mode reflects the LED light on the skin, which is received by the detector, and quantified in a similar fashion through the use of filters and converters.

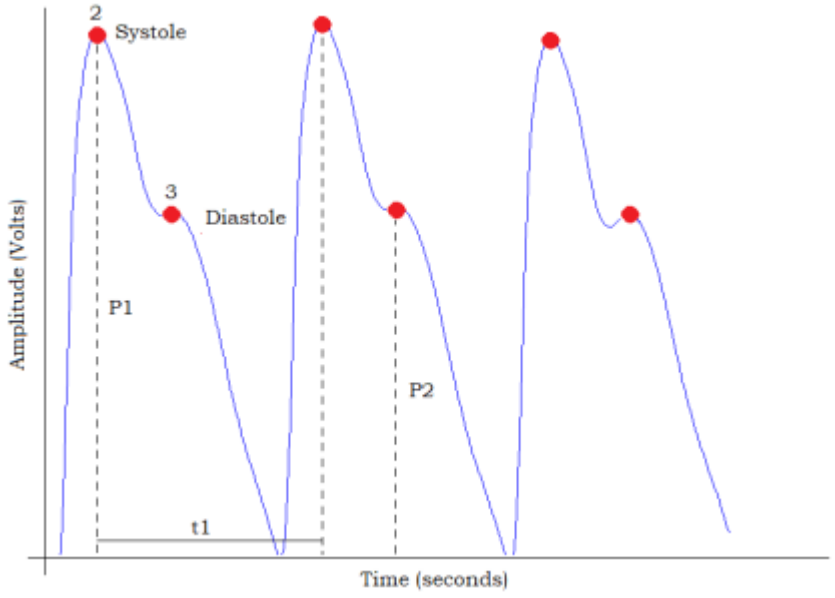


Figure 4. PPG signal analysis.

t_1 = time interval between beats

$HR_{inst} = 60 / t_1$

1.2.5 Common Types of Devices:

1.2.5.1 Chest-band devices.

These devices use electrical detection to track your heart rate. They detect electrical activity through a band that wraps around your chest. For most of these devices to work as designed, the band must be wet, or you need to use a conductive gel where the sensors touch your skin. Water or conductive gel improves electrical conduction, so it's easier for the device to detect your heart's electrical current.

- **Electrodes**: The chest strap contains embedded electrodes, which are in direct contact with your skin. These electrodes are typically placed near the heart, around the chest.
- **Detecting Electrical Signals**: As your heart beats, it generates electrical signals. The electrodes in the chest strap detect these electrical signals, which are related to the contraction of the heart muscles.
- **Signal Processing**: The detected electrical signals are sent to the transmitter, which is often embedded in the chest strap itself.

- **Data Transmission**: The transmitter processes these signals to determine your heart rate, usually measured in beats per minute (BPM). The processed data is then wirelessly transmitted to a receiving device, such as a smartwatch, smartphone, or fitness tracker, using Bluetooth or ANT+ technology.
- **Displaying Data**: The receiving device receives the heart rate data and displays it in real time. Some devices may also store this data for later analysis.
- **Additional Features**: Advanced receiving devices can analyze the heart rate data to provide insights into your fitness level, training intensity, and overall cardiovascular health.
- The chest strap and transmitter are usually **powered** by a small battery, which can last for several months to a year depending on usage.

1.2.5.2 Wrist- or forearm-worn wearables:

There are two major arteries in your forearm and wrist. The radial artery runs toward your thumb, and the ulnar artery runs toward the pinky and ring fingers. These two arteries provide plenty of blood flow to the skin at the surface of your wrist and forearm. These wearables have light-emitting diodes (LEDs) and sensors that rest against the skin in that area. The sensor uses LED light to detect the tiny expansions of the blood vessels underneath the skin's surface.

Wrist- or forearm-worn wearables

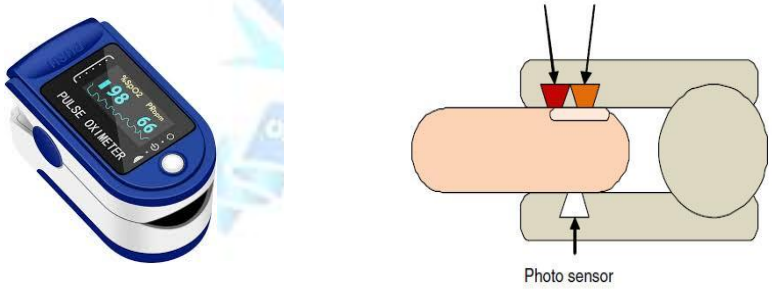
Wrist-based heart rate monitors, commonly found in fitness trackers and smartwatches, use optical sensors to measure your heart rate. Here's how they work:

1. Optical Heart Rate Monitoring (PPG)

- The core technology behind wrist-based heart rate monitors is called **Photoplethysmography (PPG)**.
- The device has LED lights (usually green) that shine light into your skin. Blood absorbs green light, so when your heart pumps blood through your veins, more light is absorbed, and less is reflected back.

A photodiode (light sensor) in the device detects the amount of light that's reflected back.

1.2.5.3. Pulse oximeters: These devices, many of which clip onto a finger, also use the optical detection method. These track pulse rate and blood oxygen levels. They're common in hospital settings, but you can also get portable, battery-powered versions of these devices for personal use.



Pulse oximeters

Working of Pulse Oximeter:

- **Light Emission:** The pulse oximeter emits red and infrared light into the blood vessels.

- **Light Absorption:** Oxygenated and deoxygenated blood absorb these wavelengths of light differently. Oxygenated blood absorbs more infrared light, while deoxygenated blood absorbs more red light.
- **Photodetector:** A photodetector measures the amount of each wavelength of light that is absorbed.
- **Calculation:** The device uses an algorithm to calculate the ratio of oxygenated to deoxygenated blood based on the light absorption data.
- **Display:** The calculated oxygen saturation level, typically expressed as a percentage (SpO2), is displayed on a screen.

1.2.5.4 Smart rings:

These are devices you wear on one of your fingers like a piece of jewellery. They also use optical detection to track your heart rate and other vital signs. These devices are still very new, and there's limited data on their accuracy.

Smart rings – Heart Rate Monitor

- Most smart rings utilize an optical sensor, often a **green LED** and a **photodiode**.
- The LED emits a green light that penetrates the skin.
- The photodiode detects the light reflected back from the blood vessels.
- The ring emits green or infrared light from tiny LEDs on its underside.
- This light shines through your skin, reaching your blood vessels.
- As your heart beats, the volume of blood in your finger changes slightly.
- This change in blood volume affects how much light is reflected back to the ring's photodetectors.
- The photodetectors measure the variations in reflected light intensity.
- These variations correspond to the changes in blood volume caused by your heartbeat.

- The ring's internal algorithms process this signal and convert it into a heart rate measurement

1.2.5.5 Smartphones – Heart rate monitor:

- Smartphones have become versatile devices that can track various health metrics, including heart rate. While the specific methods may vary slightly between different models and brands, here are the common approaches used:
  - ✓ **Green LED and Photodiode:** The most common method involves a green LED and a photodiode placed on the back of the phone.
  - ✓ **Light Absorption:** The LED emits green light, which is absorbed by the blood.
  - ✓ **Blood Flow Detection:** As the heart pumps blood, the amount of light absorbed by the blood changes. The photodiode detects these fluctuations.
  - ✓ **Heart Rate Calculation:** By analyzing the pattern of light absorption changes, the smartphone can calculate the heart rate.

- **Camera-Based Heart Rate Monitoring:**
  - ✓ **Video Analysis:** Some smartphones use the front-facing camera to capture a video of the user's face or finger.
  - ✓ **Color Changes:** The algorithm analyzes the subtle color changes in the skin caused by blood flow.
  - ✓ **Heart Rate Calculation:** By measuring the frequency of these color changes, the smartphone can estimate the heart rate.

Smartphones – Heart rate monitor

1.2.6 HOLTER MONITOR:

- A Holter monitor is a type of **portable electrocardiogram** (ECG). It records the electrical activity of the heart over **24 hours** or longer while you are away from your healthcare provider's office.
- A Holter monitor is a small, **wearable device** that records the heart's rhythm, usually for 1 to 2 days. It's used to spot irregular heartbeats, also called arrhythmias.
- A Holter monitor test may be done if a traditional electrocardiogram (ECG or EKG) doesn't provide enough details about the heart's condition.
- Some personal devices, such as **smartwatches**, offer electrocardiogram monitoring.

Working of Holter Monitor as follows

- **Electrode Placement:**

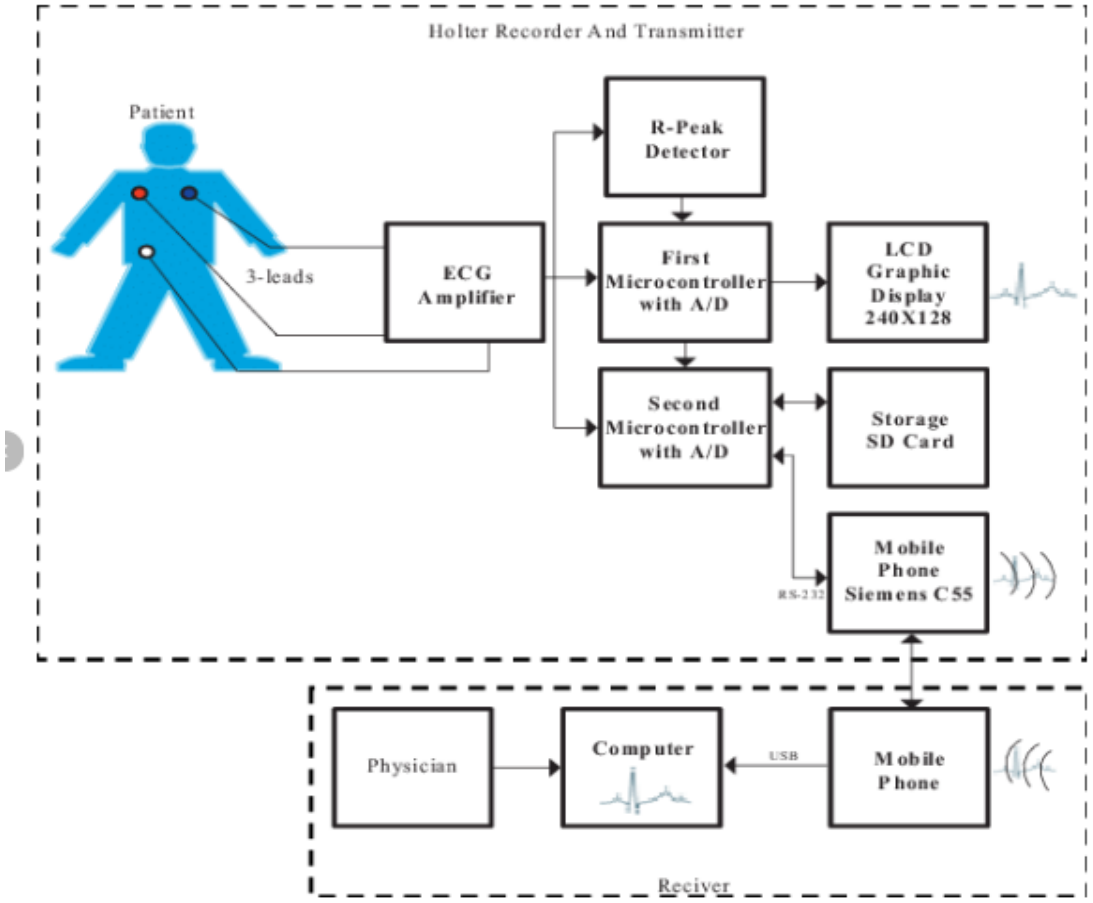
  Small adhesive electrodes are attached to the patient's chest. These electrodes are connected to the Holter monitor via lead wires. The placement of electrodes is similar to that used in a standard ECG.
- **Continuous Monitoring**: The Holter monitor records the electrical signals from the heart continuously over the monitoring period. This is different from a standard ECG, which typically only records for a few minutes.
- **Data Recording**:

  The monitor stores the data from the electrodes. This data includes the heart's electrical activity, which is displayed as an electrocardiogram (ECG) trace.
- **Daily Activities**:

  While wearing the Holter monitor, patients are usually asked to keep a diary of their daily activities, including any symptoms they experience, such as palpitations, dizziness, or chest pain. This helps correlate symptoms with the ECG data.
- **Analysis**:

  After the monitoring period, the patient returns the Holter monitor to the healthcare provider. The recorded data is then analyzed by a technician or a cardiologist to identify any abnormal heart rhythms or other issues.
- **Diagnosis**:

Based on the analysis, the healthcare provider can diagnose conditions such as arrhythmias, ischemia, or other cardiac problems, and recommend appropriate treatment or further testing if needed.



- This system consists of two main microcontrollers that have 8 channels of built-in 10-bit analog-to-digital converter (ADC) and a port for SPI interface.
- The first microcontroller is used to read a channel of 8-bit ADC from ECG signal, interface with a graphical LCD, and use the Capture/Compare/PWM (CCP) module to count the time of R-R interval from the R-peak detection circuit (Figure 3.)
- It calculates the heart rate and sends the data to the second microcontroller if heart rate is not in the normal range. The second microcontroller is used to read a channel of 8-bit ADC from ECG signal and interface with a mobile phone to send the data and warning SMS if the first microcontroller detects the abnormal heart rate. It is also used to interface to an SD card for ECG data storage.
- This system does not require any involvement or maintenance from the patient.

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