# Discovering IoT in Daily Life: A Comparison of Wrist-Based and Chest Strap Heart Rate Monitoring Technologies


## Abstract

This study compares two widely used heart rate monitoring technologies in wearable IoT devices: **wrist-based optical sensors (PPG)** and **chest strap heart rate monitors (ECG)**. While wrist-based devices offer convenience, chest straps are considered more accurate due to their direct measurement of cardiac electrical activity. Measurements were conducted using an **Apple Watch (wrist-based PPG)** and a **Polar H10 chest strap (ECG-based)** across different activity levels. The results indicate that while both methods provide similar readings at rest, **wrist-based sensors show greater deviations during intense exercise due to motion artifacts and sensor limitations**. A key research question is posed: **How do wrist-based and chest strap heart rate monitors compare in terms of accuracy and reliability under varying physical conditions?** This study highlights the trade-offs between convenience and accuracy in wearable heart rate monitoring systems.


## Introduction

Heart rate monitoring is an essential feature in modern **wearable IoT fitness devices**, used for personal health tracking, sports performance analysis, and medical applications. The two most common heart rate measurement techniques are:

1. **Wrist-based Photoplethysmography (PPG):** Uses an optical sensor to detect blood volume changes by emitting light onto the skin and analyzing the reflected signal.
2. **Chest Strap Electrocardiography (ECG):** Uses electrodes placed on the chest to directly measure the electrical signals generated by the heart.

While **PPG-based wrist monitors** (e.g., smartwatches, fitness bands) are more user-friendly and provide **continuous** heart rate tracking, **ECG-based chest straps** are considered the gold standard in sports and medical applications due to their **higher accuracy and resistance to motion artifacts**. This study compares these two technologies across different activity levels to assess their **reliability, accuracy, and usability**.

## Observation and Measurement

### Devices Used

- **Wrist-based monitor:** Apple Watch Series 9 (PPG)

- **Chest strap monitor:** Polar H10 (ECG)

**Testing Conditions**

Heart rate measurements were recorded under three conditions:

- **Resting (seated for 5 minutes, minimal movement)**
- **Walking (5 minutes at 4 km/h, moderate movement)**
- **Running (5 minutes at 10 km/h, high-intensity movement)**

The heart rate readings (beats per minute, BPM) from both devices are summarized in the table below:

| Condition | Wrist-Based (PPG, BPM) | Chest Strap (ECG, BPM) | Difference (%) |
|---|---|---|---|
| Resting | 72 | 71 | +1.4% |
| Walking | 98 | 96 | +2.1% |
| Running | 160 | 150 | +6.7% |

## Findings

1. **At rest, both devices produced nearly identical results** (±2% variation).
2. **During moderate movement (walking), wrist-based sensors maintained reasonable accuracy** but showed slightly higher fluctuations.
3. **During intense exercise (running), wrist-based measurements deviated significantly from the ECG chest strap, overestimating heart rate by up to 10 BPM**. This discrepancy is likely due to **motion artifacts, wrist positioning, and PPG sensor limitations**.
4. **The chest strap provided stable and accurate readings across all conditions**, reinforcing its reliability for high-intensity training and medical applications.

## Problem or Research Question

Based on these observations, the key research question is:
**How does wrist-based heart rate monitoring compare to chest strap ECG in terms of accuracy and reliability across different physical activity levels?**

Wrist-based PPG sensors provide convenience but are more susceptible to errors during movement. Factors such as **skin tone, ambient light, motion artifacts, and sensor placement** can impact measurement accuracy. In contrast, chest straps deliver consistent

ECG readings but require **direct skin contact and proper positioning**, making them less convenient for casual use.

Further research could focus on **enhancing PPG algorithms, reducing motion artifacts, and developing hybrid PPG-ECG wearables** that combine the strengths of both technologies.

## Conclusion

This study compared **wrist-based (PPG) and chest strap (ECG) heart rate monitoring technologies**, highlighting their strengths and weaknesses. **PPG-based wrist monitors are ideal for casual and continuous tracking but suffer from accuracy issues during high-intensity activities**. **ECG chest straps provide superior accuracy but require proper positioning and direct skin contact**. Future improvements in **sensor technology, AI-driven noise reduction, and hybrid monitoring solutions** could bridge the accuracy gap, making wrist-based heart rate tracking more reliable for professional athletes and medical applications.