



Opportunities for photoplethysmography in public health



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**Every 15 mins
in UK:**

3

**hospital
admissions**

5

deaths

**£250,
000**

**healthcare
costs**





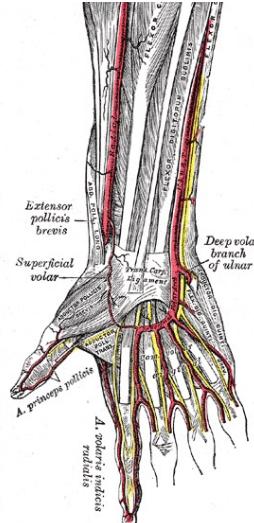
Max Health Band

VO₂ max
Stress level
Heart rate
Respiratory rate
Blood pressure
Energy expenditure
Sleep assessment
Oxygen saturation
Arrhythmias
Vascular age

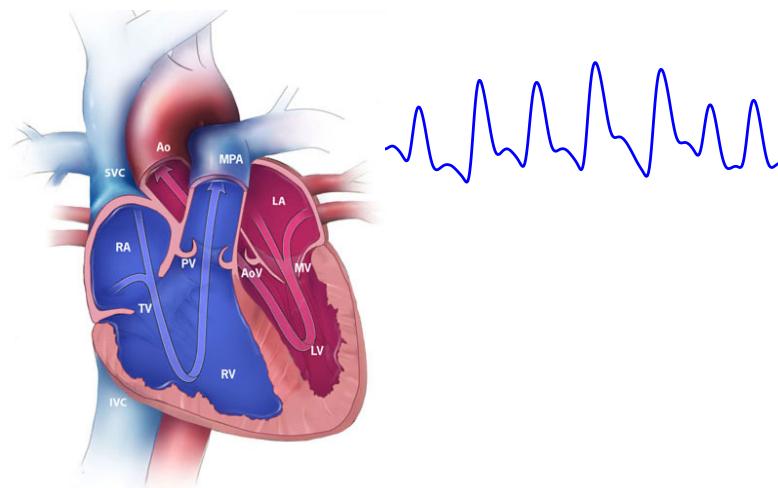




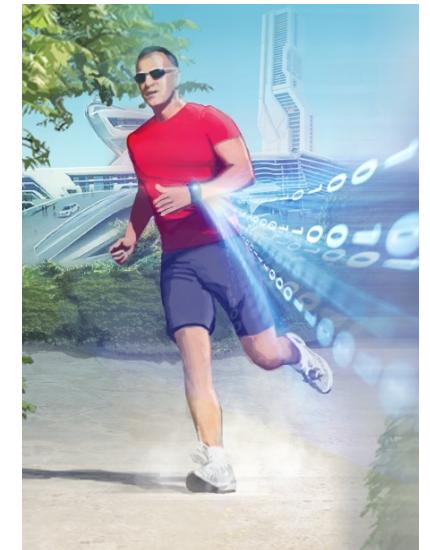
Fundamentals of photoplethysmography



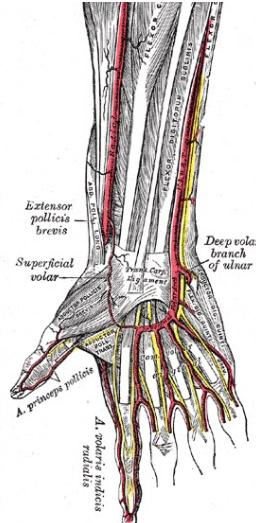
Opportunities in public health



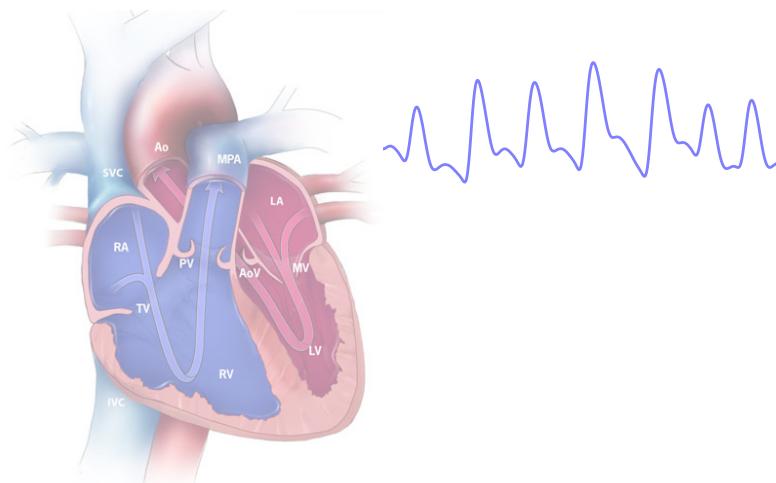
Future Research



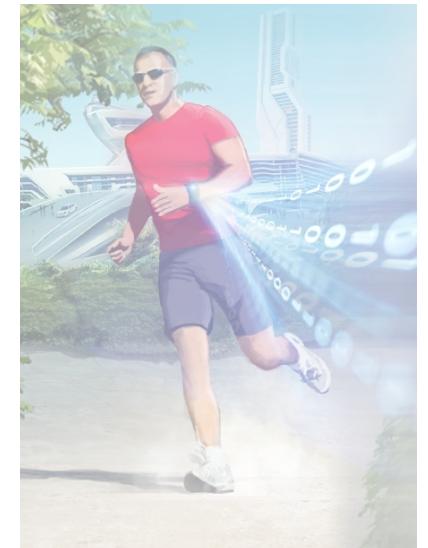
Fundamentals of photoplethysmography

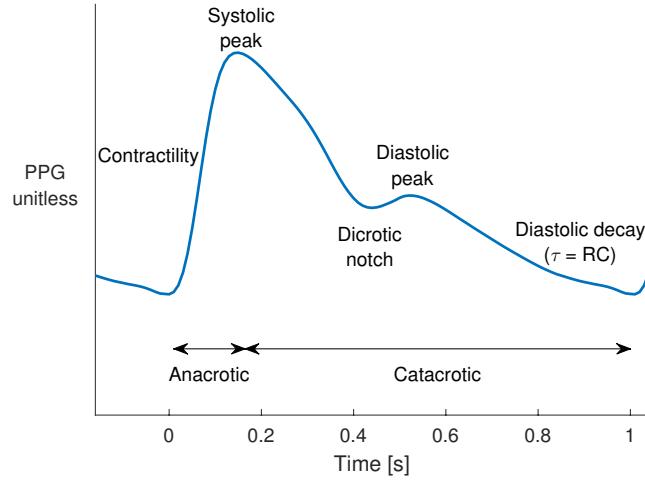


Opportunities in public health



Future Research





Photoplethysmography, 1930s



Clinical

Pulse oximetry in hospital, 1980s

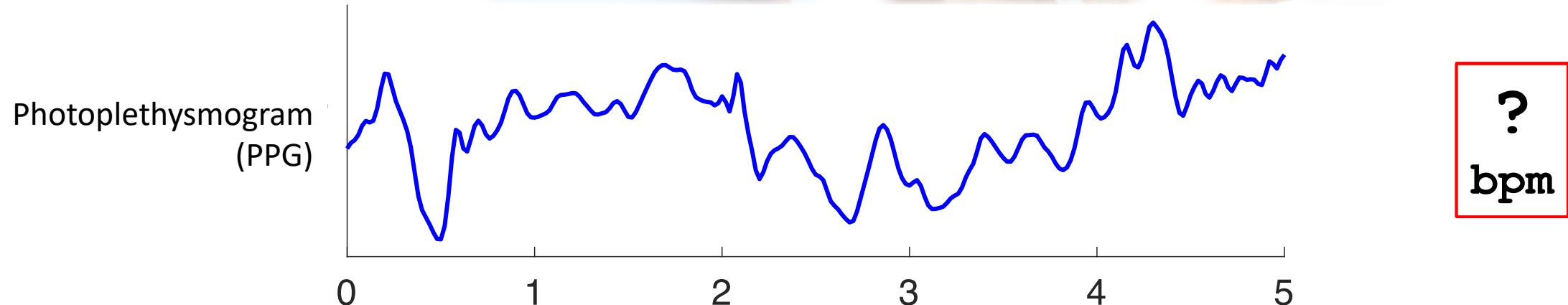


Optical Heart Rate Monitor, 2013



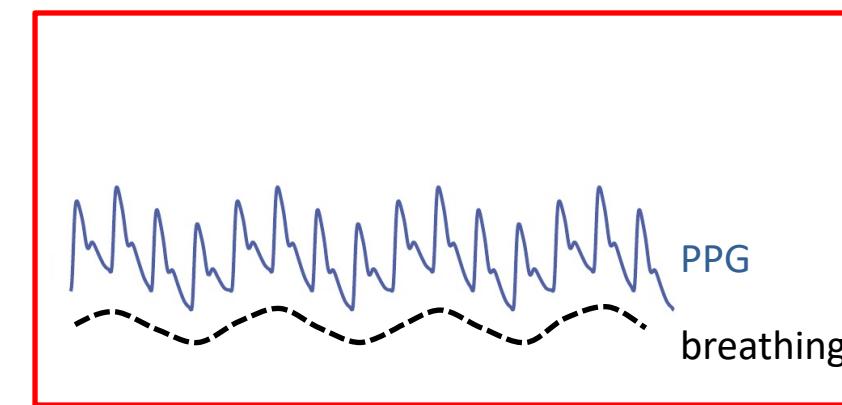
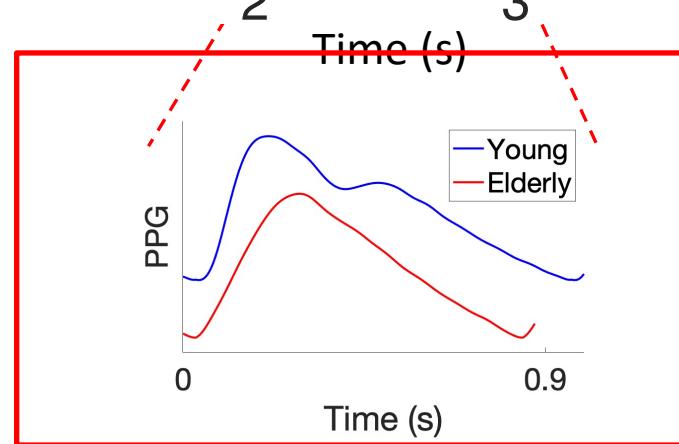
Consumer



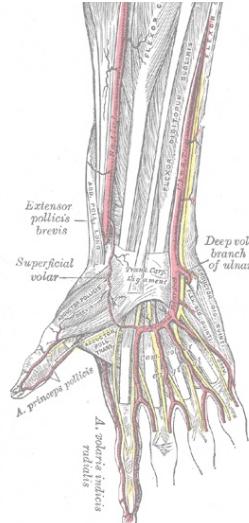


Normal rhythm

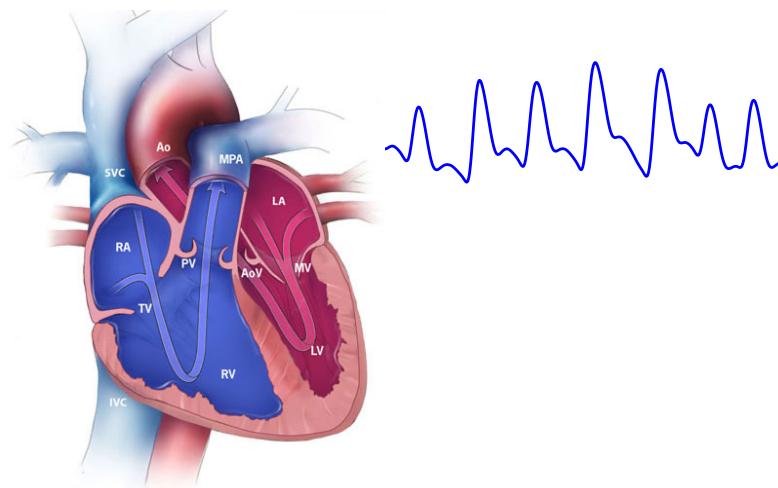
Arrhythmia



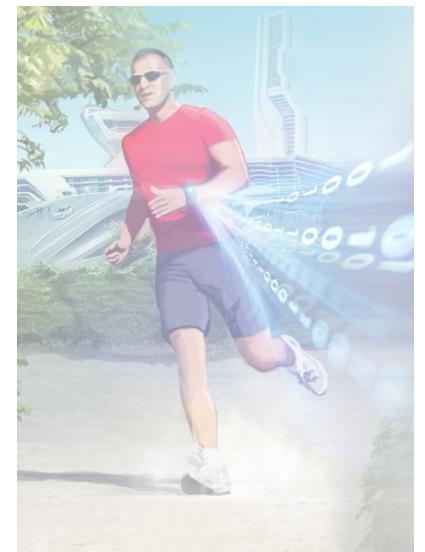
Fundamentals of photoplethysmography



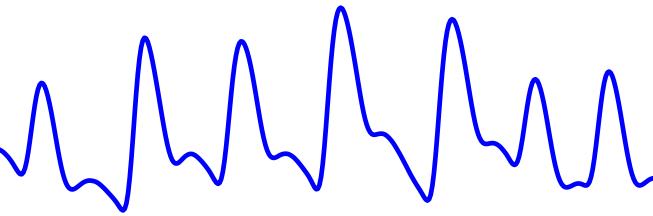
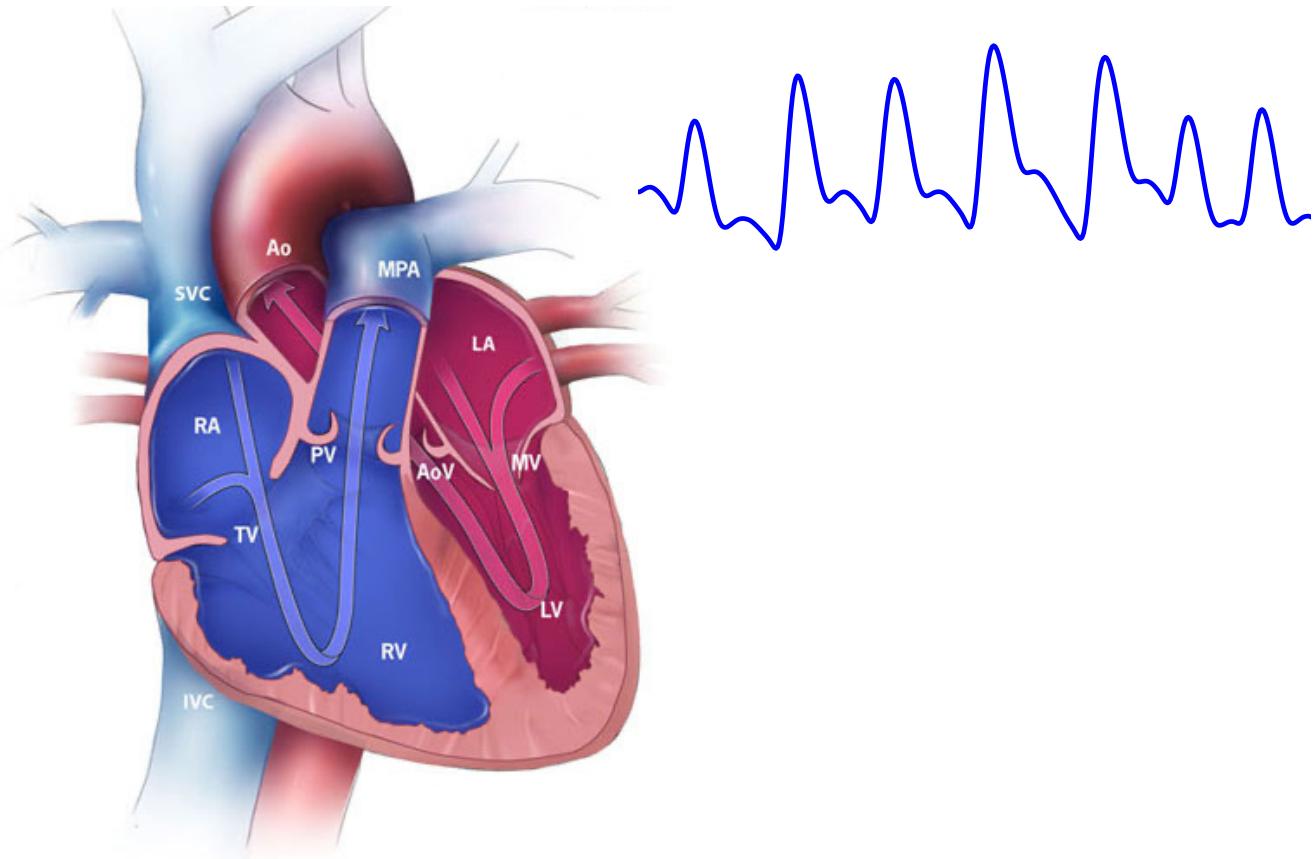
Opportunities in public health



Future Research



Identifying Atrial Fibrillation



If atrial fibrillation
was adequately
treated in England:

2,000

Lives saved
p.a.

7,000

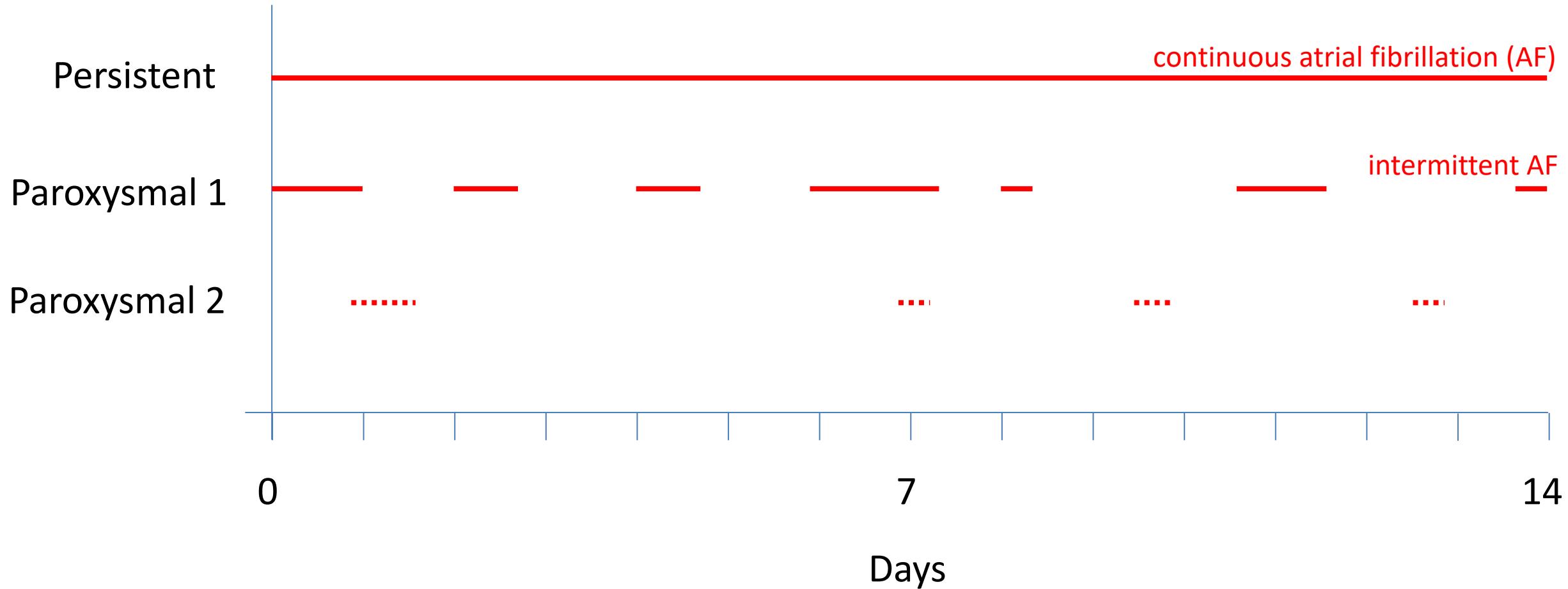
Strokes
prevented p.a.

425,
000

Additional
diagnoses



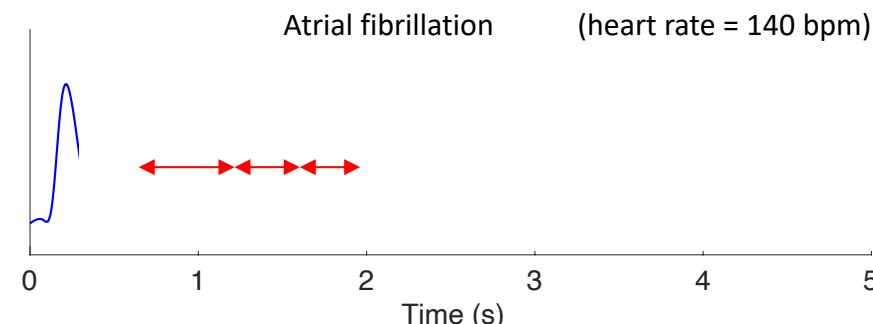
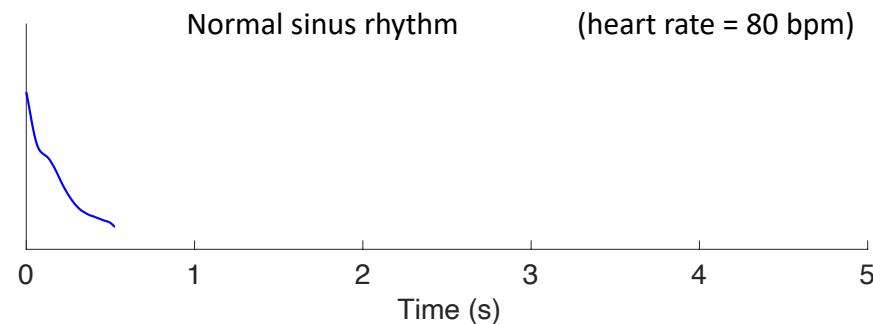
Identifying Atrial Fibrillation



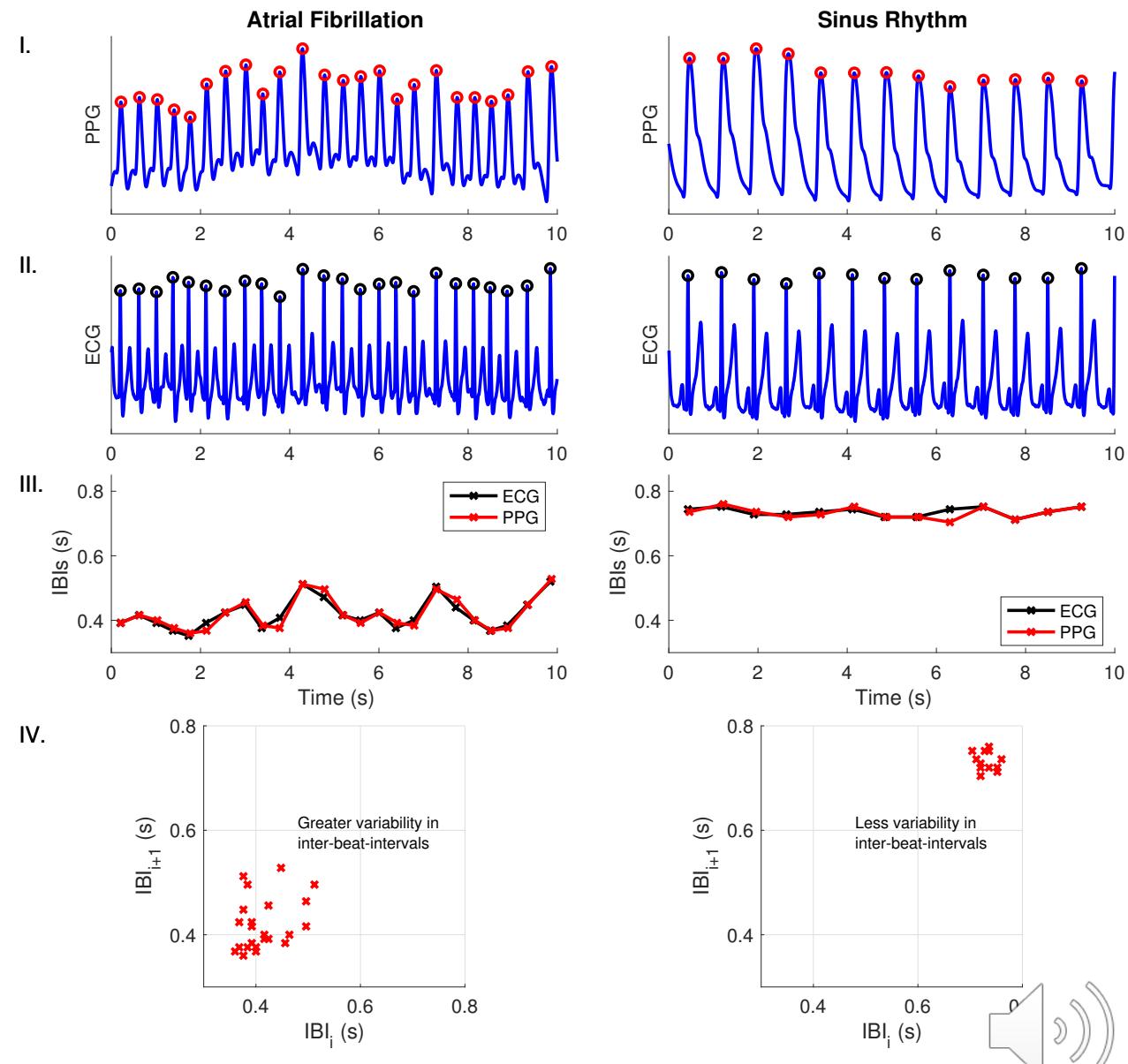
Days



Identifying Atrial Fibrillation



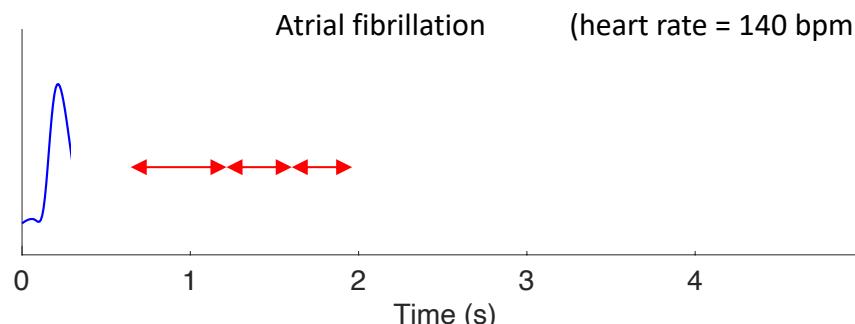
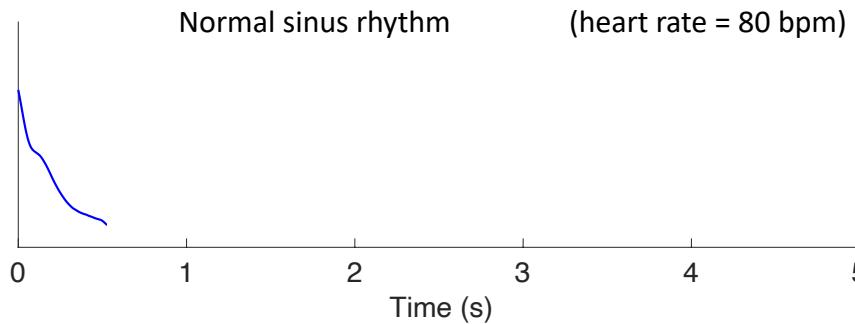
Irregular beat-to-beat intervals



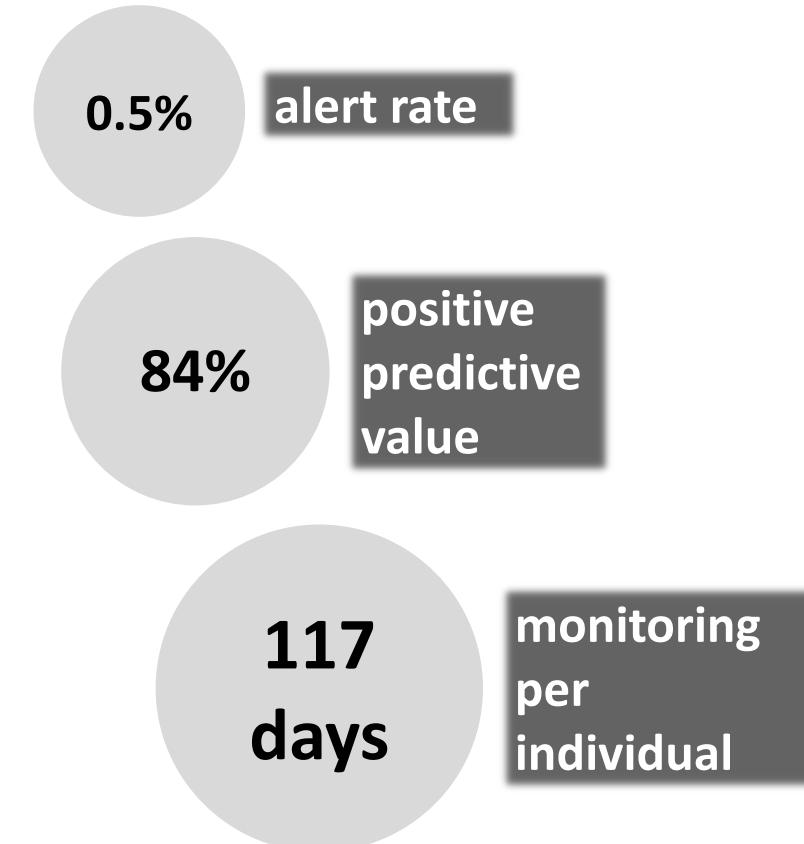
Identifying Atrial Fibrillation



Perez M.V. et al. Large-scale assessment of a smartwatch to identify atrial fibrillation. *N. Engl. J. Med.* **2019**, *381*, 1909–1917, doi:[10.1056/NEJMoa1901183](https://doi.org/10.1056/NEJMoa1901183)



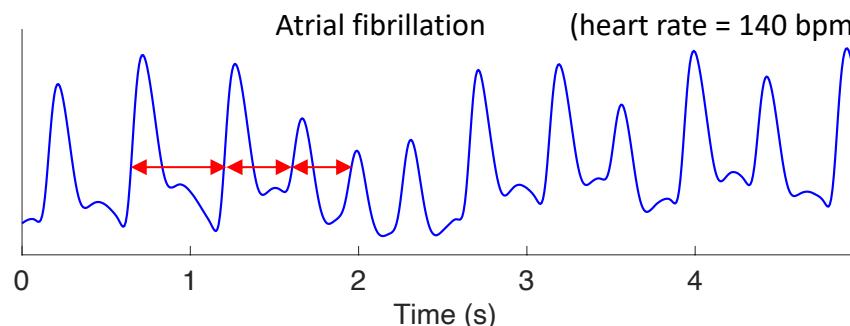
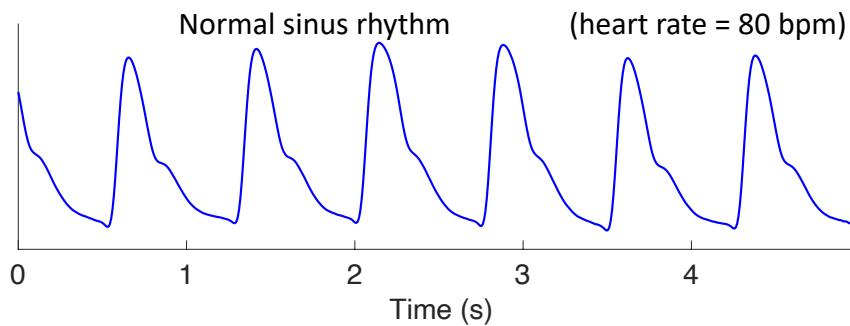
Irregular beat-to-beat intervals



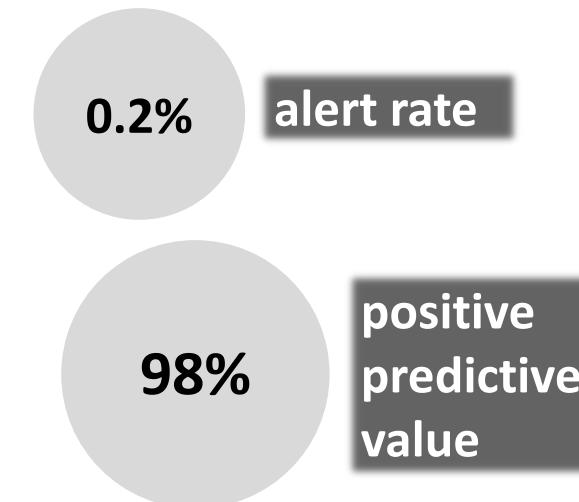
Identifying Atrial Fibrillation



Lubitz S. et al. Detection of Atrial Fibrillation in a Large Population using Wearable Devices: The Fitbit Heart Study. *Circulation*. 2022, doi: [10.1161/CIR.0000000000001041](https://doi.org/10.1161/CIR.0000000000001041)



Irregular beat-to-beat intervals

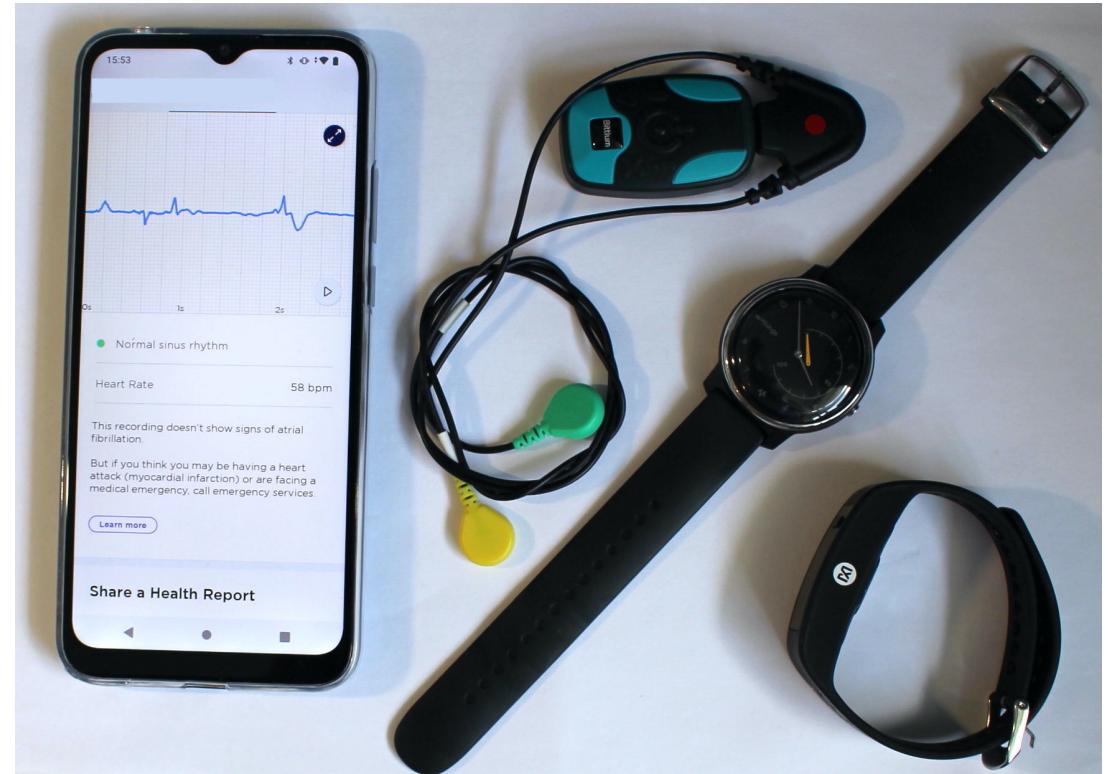


Identifying Atrial Fibrillation



SAFER Wearables Study

- Assessing performance and acceptability of wearables for detecting atrial fibrillation (AF)
- In older adults, half of whom have AF
- Two wrist-worn devices: ECG and PPG
- Reference ECG chest-patch
- Further details: [NCT0471555](#)



Identifying Obstructive Sleep Apnea



Key publications:

- Behar *et al.*, [Feasibility of single channel oximetry for mass screening of obstructive sleep apnea,](#) *EClinicalMedicine*, 2019
- Behar *et al.*, [Single-channel oximetry monitor versus in-lab polysomnography oximetry analysis: Does it make a difference?](#), *Physiological Measurement*, 2020



Infectious Diseases



Fitness trackers of the future ...

Influenza-like illness

**Resting
heart rate**

**Sleep
duration**

Radin *et al.* [Harnessing wearable device data to improve state-level real-time surveillance of influenza-like illness in the USA: a population-based study](#). *Lancet Digit. Heal.* 2020

COVID-19

**Heart
rate**

Sleep

Activity

Quer *et al.*, [Wearable sensor data and self-reported symptoms for COVID-19 detection](#). *Nat Med*, 2020

Gadaleta *et al.* [Passive detection of COVID-19 with wearable sensors and explainable machine learning algorithms](#). *npj Digit Med*, 2021



Cardiovascular risk assessment



Fitness trackers of the future ...

Blood pressure

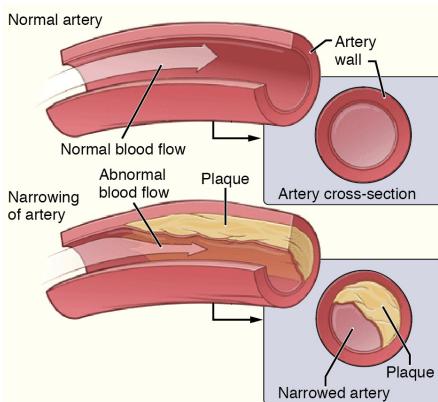
2018: Out of 532 wristbands, none were validated for blood pressure [1].

2020: Wristbands being validated and approved for blood pressure [2].

2021: Wristband wearables ... should not be used for home blood pressure monitoring [3]. A new validation standard is being developed [4].

Vascular age

- Arteriosclerosis
- Atherosclerosis



Response to exercise

- Heart rate recovery
- Walk tests in daily life

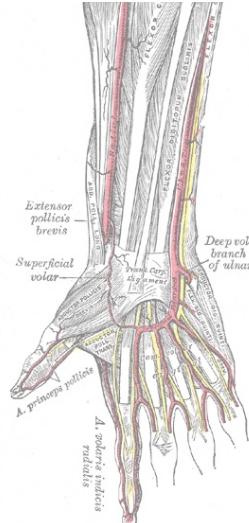
[5] Sokas D et al., [Detection of Walk Tests in Free-Living Activities Using a Wrist-Worn Device. Front Physiol](#), 2021

Gordon Betts et al., [Anatomy and Physiology](#), 2013 ([CC BY 4.0](#)). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>

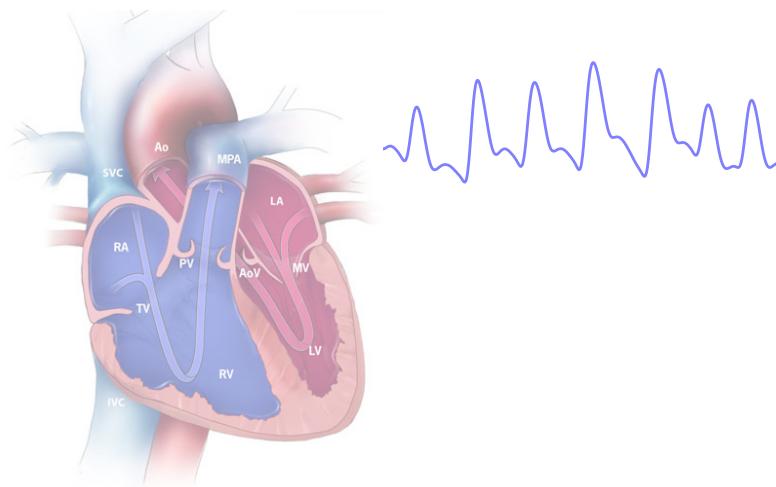


- [1] Picone et al., [Nonvalidated Home Blood Pressure Devices Dominate the Online Marketplace in Australia: Major Implications for Cardiovascular Risk Management](#). *Hypertension*, 2018
- [2] van Helmond et al., [Is cuffless blood pressure measurement already here?](#) *J Hypertens*, 2020
- [3] Stergiou et al., 2021 [European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement](#). *J Hypertens*, 2021
- [4] Mukkamala R et al., [Evaluation of the Accuracy of Cuffless Blood Pressure Measurement Devices: Challenges and Proposals](#). *Hypertension*, 2021

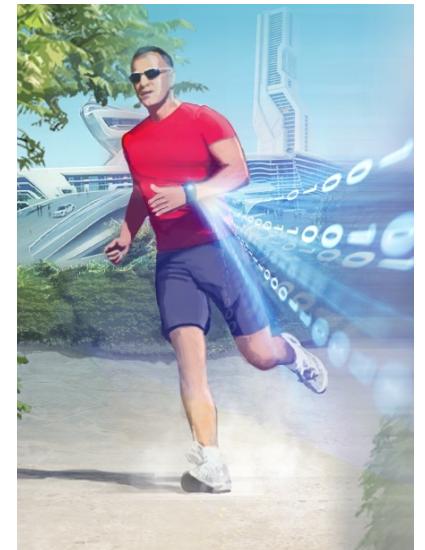
Fundamentals of photoplethysmography



Opportunities in public health



Future Research



Next Steps



Provide best
possible signals

Provide accurate
parameters

Provide clinically
useful information

Tailor wearables
to intended users

Specific applications
to improve outcomes





There is great opportunity to use photoplethysmography in public health

Clinical applications are emerging, including detecting atrial fibrillation

When used clinically, photoplethysmography should be like a climbing rope:

- highly reliable
- validated
- for specific purposes





Opportunities for photoplethysmography in public health

Much of the information in this talk is from:

Charlton P.H. et al., **Wearable photoplethysmography for cardiovascular monitoring**, *Proceedings of the IEEE*, 2022, <https://doi.org/10.1109/JPROC.2022.3149785> (CC BY 4.0)



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