BI7

Comparison of perfusion index obtained by smartwatch and pulse oximeter

Matej LOSOS

Department of Biomedical Technology, Faculty of Biomedical Engineering,
Czech Technical University in Prague, Kladno, Czech Republic,
lososmat@student.cvut.cz

Introduction

Pulse oximetry is a common non-invasive method for monitoring oxygen saturation (SpO_2), and photoplethysmography (PPG) signals are increasingly used to assess the perfusion index (PI), reflecting the ratio of pulsatile to non-pulsatile blood flow. While traditional pulse oximeters use transmission sensors on the finger, wearable devices like the Masimo W1 use reflective sensors, offering greater flexibility. Monitoring PI has clinical relevance, for example in tracking perfusion recovery after finger replantation, where finger sensors can be limiting.

This study compares the Masimo Radical-7 pulse oximeter with the W1 smartwatch, which enables peripheral perfusion monitoring without relying on finger placement—making it a promising tool in situations with restricted finger access.

Methods

This interventional prospective study evaluated the accuracy of pulse oximeter and smartwatch under controlled physiological conditions, including rest and exercise on a bicycle ergometer. The study was approved by the Institutional Review Board of FBME CTU (Act No. B10/2024). Forty-two healthy participants participated in.

Upon arrival, the participant provided informed consent and then lay down on a medical bed. The monitoring devices, including the Masimo W1 smartwatch and the Masimo Radical 7 pulse oximeter (Masimo Corporation, Irwine, CA, USA), were attached. The experiment consisted of two separate phases: a resting phase and an increased heart rate phase. Initially, the perfusion index was monitored at rest for a period of 5 minutes. Following this, the participant proceeded to the bicycle ergometer with adjustable resistance, and once the heart rate exceeded 120 bpm, the PI progression was recorded for additional 5 minutes. The sampling frequency was 0.5 Hz.

The recorded data was further processed in the Matlab 2024b (The MathWorks, Inc., USA), and for each measuring device, the average value at each time point across all participants was calculated. Subsequently, the data were logarithmically transformed, and the relationship between the logarithmized perfusion index values of both measuring devices was first analyzed for the resting phase. For the increased heart rate phase, the data were then visualized in the graph as a normalized average value ± standard deviation.

Results

The study was conducted in the Laboratory of special equipment for ICU of the Czech Technical University in Prague, Department of Biomedical Engineering, Kladno, Czech Republic, during October 2024.

The dependence of the logarithmized PI value for the oximeter on the logarithmized PI value of the smartwatch during the resting phase is shown in Figure 1, where no clear dependency is observed. Figure 2 illustrates the temporal development of the logarithmized PI value during physical activity, showing a noticeable increase in PI along with a rise in heart rate. The trend curve of the perfusion index for the oximeter shows a growth similar to that of the smartwatch, but with an offset.

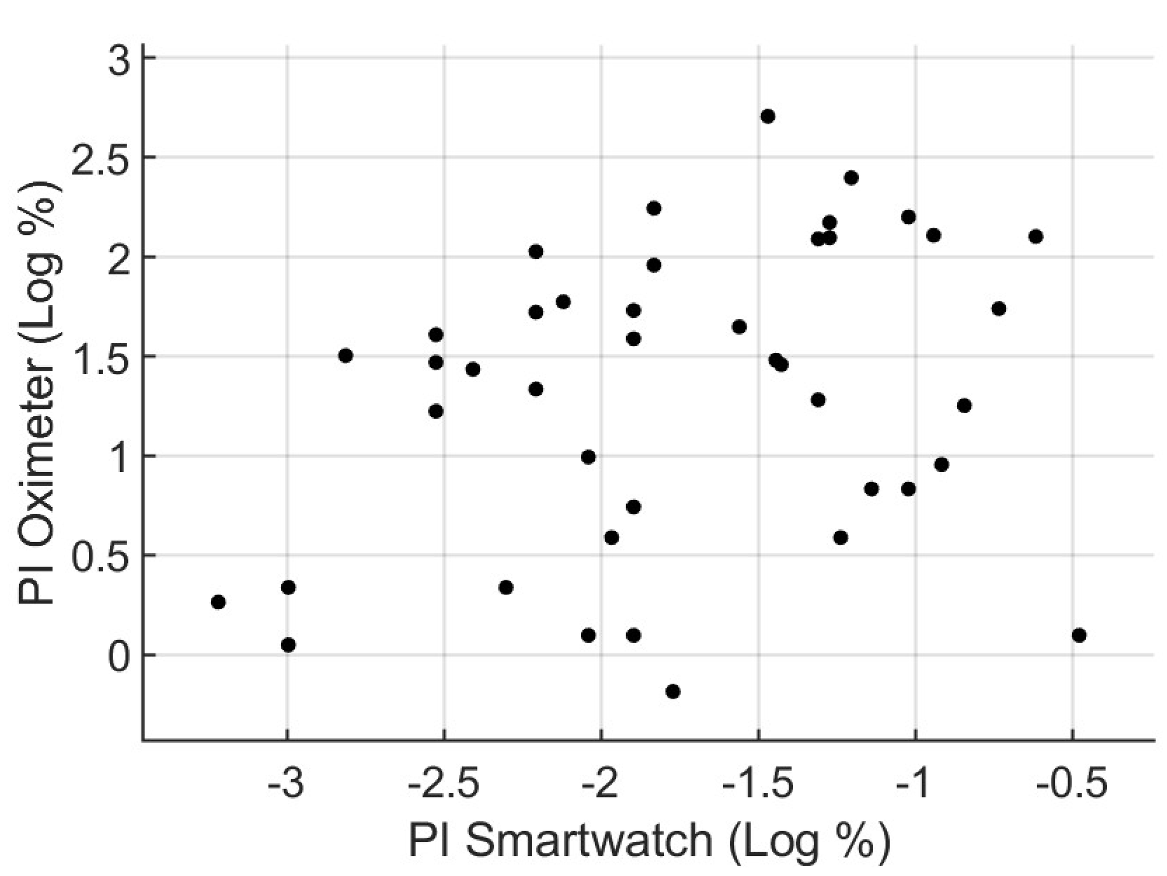

Fig. 1. Dependence of the logarithmized perfusion index values of the measuring devices.

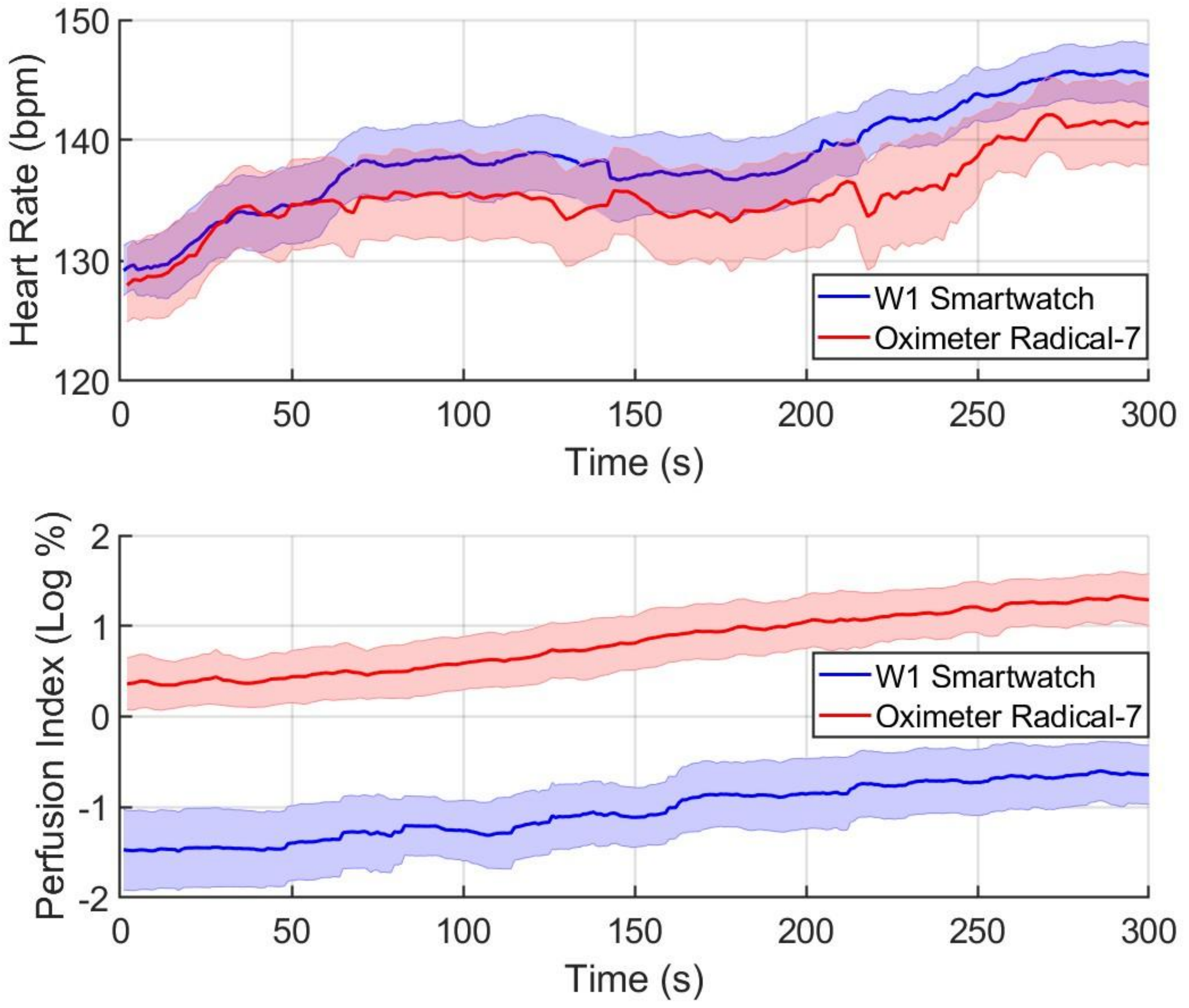

Fig. 2. Logarithmically transformed PI values as a function of time with exceeded heart rate.

Discussion

The main finding of this experiment is that the perfusion index responds to an increased heart rate by increasing its value, which was observed in both devices. In the resting phase, no dependence was observed.

Although the absolute PI values differed between the measuring devices, they exhibited the same growth trend in response to increased heart rate. This confirms that while different sensor technologies may introduce systematic offsets, the overall response pattern remains consistent. As mentioned in the study by Pinto Lima, each individual has a unique baseline PI value at rest; therefore, this study focused on analyzing trends over time rather than absolute values.

One of the limitations of this study is the potential influence of external factors on the accuracy of the reflective sensor. Variables such as skin temperature or sweat on the forearm could have affected signal detection, leading to increased measurement variability. Additionally, individual differences in microcirculation and skin properties might contribute to variations in PI readings.

These findings support the use of PI as a potential marker of circulatory changes. Given its ability to reflect changes in blood perfusion, PI could play a valuable role in clinical applications, including the monitoring of tissue viability after surgical procedures such as replantation.

Conclusion

This study demonstrated that both the Masimo W1 smartwatch and the Radical-7 pulse oximeter are capable of capturing perfusion index trends in response to increased heart rate. Despite systematic differences in absolute PI values due to varying sensor technologies and placement, both devices showed a comparable directional response during exercise.

This suggests that wearable reflective sensors, such as the W1, can provide meaningful insights into peripheral perfusion dynamics. Given its independence from finger placement, the W1 smartwatch represents a promising tool for monitoring tissue perfusion in scenarios where conventional sensors are impractical, such as post-surgical recovery or finger replantation cases.

Acknowledgements

The author would like to thank to Ing. Simon Walzel for his valuable advice and assistance during the experiment, and to all the participants who attended and dedicated their time and patience. This work was supported by the Grant Agency of the Czech Technical University in Prague, Grant No. SGS25/110/OHK4/2T/17.