

Wrist-Worn Wearables for Monitoring in the Perioperative Setting: Validation Study of Heart Rate and Oxygen Saturation Sensors

Eduardo Salgado^{1,2}, Charlotte Köhler³, Adam Wolisz⁴, Thorsten Schaaf², Daniel Fürstenau², Felix Balzer², Sylvia Thun⁵, Alexander Bartschke⁵

¹Department of Anesthesiology and Intensive Care Medicine, Charité – Universitätsmedizin Berlin, Berlin, Germany

²Institute of Medical Informatics, Charité – Universitätsmedizin Berlin, Berlin, Germany

³Department for Data Science & Decision Support, European University Viadrina, Frankfurt (Oder)

⁴Faculty IV - Electrical Engineering and Computer Science, Technische Universität Berlin

⁵Core Facility Digital Medicine and Interoperability, Berlin Institute of Health at Charité – Universitätsmedizin Berlin, Berlin, Germany

Introduction

Wearables have become widespread consumer health products with sensors measuring a wide range of vital signs. Using these to monitor patients in a perioperative setting could bring numerous benefits such as early discharge from the hospital and remote rehabilitation; yet their clinical implementation remains a challenge as their monitoring capabilities need to be validated. This study aims to evaluate the accuracy and validity of heart rate (HR) and oxygen saturation (SpO₂) sensors of four popular devices from Apple, Samsung, Garmin, and Withings in comparison with a gold standard monitor currently used in operating rooms and intensive care units.

Methods

We conducted measurements of HR and SpO₂ in 10 healthy subjects (American Society of Anesthesiologists class I). For each subject, we conducted three supervised measures at rest to compare the validity and accuracy of the wearables (Apple Watch Series 6, Samsung Galaxy Watch3, Garmin Venu 2, and Withings ScanWatch) following the instructions provided by the manufacturer against the Philips Intellivue X3 monitor. All subjects signed an inform consent in accordance with the Declaration of Helsinki and the study was approved by the local ethics committee



Apple Watch® Series 6



Samsung® Galaxy Watch3



Withings® ScanWatch



Garmin® Venu2



Gold Standard: Philips Intellivue X3

Results



Figure 1. HF and SPO₂ Measurements of Smartwatches and Gold Standard Monitor

We find that all wearables measure HR with acceptable standardized typical error and indicate significant correlations with the medical monitor, being Garmin and Samsung the smartwatches that provide the highest HR validity. In contrast, the SpO₂ measures were much more inaccurate with a higher standardized error, nevertheless Apple and Garmin delivered a good correlation and the highest SpO₂ validity of all four devices. Moreover, we observed that all four smartwatches deliver on average a 2% lower SpO₂ than the gold standard. Results from Apple and Withings smartwatches need to be further analyzed with caution and a with more significant number of subjects, due to relatively higher error rates.

Conclusion

Our results show that wearables have the potential to substitute traditional clinical monitoring by delivering reliable data that could be used for patient care. However, we find differences in the accuracy and hence the validity of smartwatches tested. In the future, we will extend our methodological setting to investigate better the reliability of integrating smartwatches in perioperative care. This will include testing more smartwatch devices and subjects (with and without medical conditions), as well as long-term unsupervised monitoring and analysis to detect or exclude possible systematic errors in the measurements.

References

Hernando, D., Garatachea, N., Almeida, R., Casajús, J. A., & Bailón, R. (2018). Validation of Heart Rate Monitor Polar RS800 for Heart Rate Variability Analysis During Exercise. *Journal of strength and conditioning research*, 32(3), 716–725. <https://doi.org/10.1519/JSC.0000000000001662>

Pasricha, S. (2023). Ethics for Digital Medicine: A Path for Ethical Emerging Medical IoT Design. *Computer*, 56(7), 32–40.

Supported by

EINSTEIN
CENTER
Digital Future

CHARITÉ
UNIVERSITÄTSMEDIZIN BERLIN

BIH Berlin Institute
of Health
@Charité