npj | digital medicine

Editorial

Published in partnership with Seoul National University Bundang Hospital

https://doi.org/10.1038/s41746-024-01341-z

The utility of personal wearable data in long COVID and personalized patient care

Radin et al.'s recent study on patients with long COVID demonstrates that personal wearable data can provide critical insight into complex conditions. This editorial argues that research insights gained through personal wearables support the integration of personal wearables into healthcare. Challenges in incorporating wearable data in the clinic point towards AI data sorting, data sharing, device interoperability, FDA oversight, and expanded insurance coverage as first steps towards addressing these challenges.

In March 2020, as the World Health Organization declared the outbreak of COVID-19 a pandemic, reports were already beginning to emerge of patients suffering from persistent symptoms following acute SARS-CoV-2 infection[1,2]. The phrase "long COVID" was coined by patients to describe both these persistent symptoms and the development of new conditions linked to SARS-CoV-2 infection[1]. Electronic health records and register data have been used to link risk factors[3,4] associated with the development of long COVID. Similarly, personal wearable device data has been used to predict the diagnosis of acute COVID-19[5] and monitor recovery[6]. Nonetheless, longitudinal information on physiological changes in individuals before and after a diagnosis of long COVID is lacking. A recent prospective study by Radin et al.[7] fills this gap in research by using data from personal wearable devices to measure objective physiologic derangements prior to infection in individuals experiencing long COVID. This study highlights the potential of personal wearables to provide longitudinal insight into patients' health for research and clinical purposes and sparks consideration of the changes required to incorporate wearable data into clinical healthcare.

Wearable data provides insight into physiological changes associated with long COVID

Using data from participants' personal fitness trackers and smartwatches, Radin et al.[7] compared heart rate, activity level, and sleep quantity measurements in individuals before and after SARS-CoV-2 infection, and between individuals with and without long COVID. Among individuals experiencing long COVID, resting heart rate did not return to pre-infection baseline until an average of 133 days following symptom onset, compared to 71 days post symptom onset for those without long COVID. Increased resting heart rate is associated with major vascular events[8], and all-cause mortality[9] and supports "prolonged physiologic derangement" in individuals with long COVID[7]. No differences in return to baseline activity level or sleep quantity were noted between those with and without long COVID. Taken together, these personal wearable data clarify persistent derangements in long COVID and inspire consideration of how such data could be employed to provide similar insights in clinical healthcare.

The promises of smart-watch data in research and patient care

Radin et al.'s[7] findings highlight the potential to use personal wearable data for longitudinal quantification of health. While one in five Americans wears a fitness tracker or smartwatch, the use of personal wearable data in clinical research has yet to reach its full potential, and use in patient care remains limited[10]. Incorporating personal wearable data in research enables easier determination of causality by allowing for data comparison before and after infection, malignancy, or administration of an intervention, and suggests the potential of wearables to provide temporal information about changes in individual patients' health in the clinical setting. Similarly, as proven by studies on the clinical effectiveness of continuous glucose monitoring for diabetes management, personal biometric data measured by wearable devices captures a larger number of datapoints over a longer time period, offering insight into patients' long-term, consistent behaviors and health patterns that isolated clinic data risks missing[11–13].

Addressing potential pitfalls of utilizing smart-watch data in patient care

Access to the expanded dataset of personal wearable data comes with limitations, including time constraints for providers who already feel overwhelmed by the amount of data available for each patient[14], concerns over the quality and consistency of data produced across smart devices[15], and uncertainties on how these data should influence patient care[16]. Furthermore, inequities persist in who can access and pay for fitness trackers and smart devices, raising concerns about how differences in access could lead to differences in the quality of care between patients with and without personal wearable data[17]. The decision of which biomarkers to prioritize in clinical healthcare of all those collected by personal wearables also brings challenges, as certain digital markers may capture risk patterns for some diseases better than for others[18]. Clearly, the incorporation of personal wearable data into research and clinical spaces will require adaptations. As a start, challenges with implementation and inequities could be addressed by:

i. Use of artificial intelligence (AI) models to streamline wearable data analysis. AI models can rapidly sort and analyze vast amounts of patient information[19], and could be employed to decrease provider burden in the analysis of data collected by personal wearable devices. Already, machine learning models have proven capable of analyzing large amounts of patient data to stratify disease risk[20], and personal wearable data could enhance such AI prediction tools without imposing additional requirements on providers.

ii. Increased collaboration, compatibility, and data sharing among technology companies in the personal wearable sector. Despite the high prevalence of personal wearable devices, the wearable industry remains fragmented[21]. Data sharing across companies could validate the reliability of models and improve the consistency and quality of data across devices. Furthermore, interoperability of different wearables would allow for easier integration of wearable technology into the healthcare system and easier interpretation of wearable data generated by difference devices[17].

iii. Increased regulation of data quality and collection techniques for smart-watch and fitness tracker companies. Should physicians use personal wearable data to guide patient care, FDA oversight must be extended, requiring additional regulatory guidance and quality standards currently lacking in the field. This oversight would presumably produce mandated standards, thereby further increasing interoperability across wearable devices, as well.

iv. A push for insurance companies to cover smartwatches and fitness trackers as they do other medical devices. While the FDA classification of personal wearables as medical devices would make such coverage more likely, a policy shift of this scope seems likely to require further evidence of improved patient outcomes and reduced insurance costs associated with the use of personal wearable data. More research into the health and cost effects of incorporating personal wearable data into the clinic is needed to propel such potential coverage forward.

v. Identification of digital biomarkers most sensitive to change and appropriate for different patient populations. Digital biomarkers that measure resilience (i.e., heart rate variability) have been proposed as markers to assess a variety of distinct conditions, including vascular homeostasis, glucose regulation, and chronic inflammation[18]. Similarly, markers that capture movement data have been proposed as prediction tools to determine mood disorder status[22] and disease progression in neuromuscular disorders[23]. Given patients' unique histories and baseline risk profiles, it is likely that different digital biomarkers will prove most useful in different clinical contexts. Further research is again required to identify which markers prove most universally important, and which will serve as critical tools in risk stratification for specific patient populations.

The challenges of incorporating personal wearable data are certainly formidable. Nonetheless, as Radin et al.'s[7] work reveals, personal wearable data provides temporal insight that isolated clinical and research data threaten to miss. The potential for wearables to provide increasingly comprehensive and personalized care necessitates conversation within the healthcare industry about how personal device data can be incorporated into healthcare, and the above adjustments offer initial guidance on the changes that must be considered to realize the potential of these data in personalizing care.

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Received: 11 October 2024; Accepted: 12 November 2024
Published online: 18 November 2024

References

1. Callard, F. & Perego, E. How and why patients made long Covid. *Soc. Sci. Med.* **268**, 113426 (2021).
2. Davis, H. E., McCorkell, L., Vogel, J. M. & Topol, E. J. Long COVID: major findings, mechanisms and recommendations. *Nat. Rev. Microbiol.* **21**, 133–146 (2023).
3. Reme, B.-A., Gjesvik, J. & Magnusson, K. Predictors of the post-COVID condition following mild SARS-CoV-2 infection. *Nat. Commun.* **14**, 5839 (2023).
4. Zang, C. et al. Identification of risk factors of Long COVID and predictive modeling in the RECOVER EHR cohorts. *Commun. Med.* **4**, 130 (2024).
5. Hirten, R. P. et al. Use of physiological data from a wearable device to identify SARS-CoV-2 infection and symptoms and predict COVID-19 diagnosis: observational study. *J. Med. Internet Res.* **23**, e26107 (2021).
6. Radin, J. M. et al. Assessment of prolonged physiological and behavioral changes associated with COVID-19 infection. *JAMA Netw. Open* **4**, e2115959 (2021).
7. Radin, J. M. et al. Long-term changes in wearable sensor data in people with and without Long Covid. *NPJ Digit. Med.* **7**, 246 (2024).
8. Lonn, E. M. et al. Heart rate is associated with increased risk of major cardiovascular events, cardiovascular and all-cause death in patients with stable chronic cardiovascular disease: an analysis of ONTARGET/TRANSCEND. *Clin. Res. Cardiol.* **103**, 149–159 (2014).
9. Vazir, A. et al. Association of resting heart rate and temporal changes in heart rate with outcomes in participants of the Atherosclerosis Risk in Communities study. *JAMA Cardiol.* **3**, 200–206 (2018).
10. Blazina, C. About one-in-five Americans use a smart watch or fitness tracker. http://www.pewresearch.org/short-reads/2020/01/09/about-one-in-five-americans-use-a-smart-watch-or-fitness-tracker/ (Pew Research Center, 2020).
11. Maiorino, M. I. et al. Effects of continuous glucose monitoring on metrics of glycemic control in diabetes: a systematic review with meta-analysis of randomized controlled trials. *Diabetes Care* **43**, 1146–1156 (2020).
12. Laffel, L. M. et al. Effect of continuous glucose monitoring on glycemic control in adolescents and young adults with type 1 diabetes: a randomized clinical trial: a randomized clinical trial. *JAMA* **323**, 2388–2396 (2020).
13. Martens, T. et al. Effect of continuous glucose monitoring on glycemic control in patients with type 2 diabetes treated with basal insulin: a randomized clinical trial. *JAMA* **325**, 2262 (2021).
14. Hall, A. & Walton, G. Information overload within the health care system: a literature review: Information overload, Amanda Hall & Graham Walton. *Health Info. Libr. J.* **21**, 102–108 (2004).
15. Cho, S., Ensari, I., Weng, C., Kahn, M. G. & Natarajan, K. Factors affecting the quality of person-generated wearable device data and associated challenges: rapid systematic review. *JMIR MHealth UHealth* **9**, e20738 (2021).
16. Azodo, I., Williams, R., Sheikh, A. & Cresswell, K. Opportunities and challenges surrounding the use of data from wearable sensor devices in health care: qualitative interview study. *J. Med. Internet Res.* **22**, e19542 (2020).
17. Canali, S., Schiaffonati, V. & Aliverti, A. Challenges and recommendations for wearable devices in digital health: data quality, interoperability, health equity, fairness. *PLoS Digit. Health* **1**, e0000104 (2022).
18. van den Brink, W. et al. Digital resilience biomarkers for personalized health maintenance and disease prevention. *Front. Digit. Health* **2**, 614670 (2020).
19. Beam, A. L. & Kohane, I. S. Big data and machine learning in health care. *JAMA* **319**, 1317–1318 (2018).
20. Krishnan, G. et al. Artificial intelligence in clinical medicine: catalyzing a sustainable global healthcare paradigm. *Front. Artif. Intell.* **6**, 1227091 (2023).
21. Bhaltadak, V., Ghewade, B. & Yelne, S. A comprehensive review on advancements in wearable technologies: revolutionizing cardiovascular medicine. *Cureus* **16**, e61312 (2024).
22. Jacobson, N. C., Weingarden, H. & Wilhelm, S. Digital biomarkers of mood disorders and symptom change. *NPJ Digit. Med.* **2**, 3 (2019).
23. Youn, B.-Y. et al. Digital biomarkers for neuromuscular disorders: a systematic scoping review. *Diagnostics* **11**, 1275 (2021).

Acknowledgements

This editorial did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

E.E. wrote the first draft of the manuscript. K.H., G.N., and S.W. contributed to the first draft and provided critical revisions. J.C.K. provided critical revisions. All authors have read and approved of the final manuscript.

Competing interests

J.C.K. is the editor-in-chief of *npj Digital Medicine*. All other authors declare no competing interests.