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Complete List of Authors:	Chico, Timothy; University of Sheffield, Infection, Immunity, and Cardiovasccular Disease Stamatakis, Emmanuel; University of Sydney, School of Health Sciences Ciravegna, Fabio; Università di Torino, Dipartimento di Informatica Dunn, Jessilyn; Duke University, Department of Biomedical Engineering and Department of Biostatistics & Bioinformatics Redwood, Simon; King's College London, St Thomas' Hospital Al-lamee, Rasha; Imperial College London, National Heart and Lung Institute Sofat, Reecha; University of Liverpool, Department of Pharmacology and Therapeutics Gill, Jason; University of Glasgow, British Heart Foundation Glasgow Cardiovascular Research Centre (BHF GCRC), Institute of Cardiovascular and Medical Sciences, College of Medical, Veterinary and Life Sciences
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Device-based measurement of physical activity in cardiovascular healthcare – potential and challenges

Timothy J.A. Chico[1,2], Emmanuel Stamatakis[3], Fabio Ciravegna[4], Jessilyn Dunn[5], Simon Redwood[6], Rasha Al-lamee[7], Reecha Sofat[8], Jason M.R. Gill[9]

[1]Department of Infection, Immunity and Cardiovascular Disease, The Medical School, The University of Sheffield, Sheffield, UK
[2]The British Heart Foundation Data Science Centre, Health Data Research UK, London, UK.
[3]Charles Perkins Centre, Faculty of Medicine and Health, The University of Sydney, Sydney, New South Wales, Australia.
[4]Dipartimento di Informatica, Università di Torino, Torino, Italy
[5]Department of Biomedical Engineering and Department of Biostatistics & Bioinformatics, Duke University, Durham, NC, USA.
[6]King's College London, St Thomas' Hospital, London
[7]National Heart and Lung Institute, Imperial College London
[8]Department of Pharmacology and Therapeutics, University of Liverpool, Liverpool, UK.
[9]School of Cardiovascular and Metabolic Health, University of Glasgow, Glasgow, UK

Low physical activity[1] and slow walking pace[2] have a two-way relationship with cardiovascular disease (CVD). Low physical activity increases future risk of CVD, while when CVD develops it often impairs activity. This means that wearable or smartphone-based measurement of physical activity may provide clinically useful "digital biomarkers". Clinicians predict future risk, diagnose disease, and recommend appropriate treatment, and for any biomarker to be used in healthcare, its measurement must influence these decisions to improve patient outcomes. Here we consider how this may be achieved.

Risk Prediction

Despite the clear relationship between activity and future CVD, risk prediction tools such as QRISK3 and SCORE do not include physical activity. This is despite the evidence that inclusion of *self-reported* walking pace improves prediction of CVD[3] while a fitness algorithm incorporating self-reported activity improved CVD risk classification[4]. The American Diabetes Association 60 second risk score for type 2 diabetes does includes binary self-reported activity. This suggests that device-based measurement, which more accurately and completely captures a comprehensive array of activity characteristics than self-report (including walking pace, total volume or intermittent vigorous activity) may further improve risk prediction. Importantly, unlike unmodifiable factors such as age, incorporating activity provides a non-pharmacological approach to reduce calculated future risk.

Diagnosis

Diagnosis of CVDs that impact activity (such as heart failure and symptomatic valvular heart disease) relies on self-recognised and self-reported symptoms. Patients must recognize such impacts (which are often insidious), seek medical attention, and accurately describe current levels of activity and how this has changed over time to the physician. This disadvantages people with cognitive impairment or difficulty communicating. Objective assessment of exercise capacity such as a six-minute walk test[5] is rarely used and relates poorly to what patients do in everyday life. Device-based measures that objectively quantify activity (especially if compared with a previous “baseline” to identify onset and rate of decline) would provide individualised assessments to guide decisions on diagnosis, investigation or specialist referral.

Treatment selection

Though rarely measured in clinical practice, physicians’ inferences about patients’ activity affect critical treatment decisions. Subjectively rated “frailty” influences whether a patient is offered surgery, ventilated for pneumonia, or resuscitated after cardiac arrest. Patients with heart failure are classified by the 4-point New York Heart Association (NYHA) score (1 = no limitation of activity, 4 = limitation even at rest). Many decisions, such as medication prescription, or implantation of devices such as defibrillators, are based on the NYHA class. Subjective assessment may deprive appropriate treatment to some, while subjecting others to unnecessary treatment.

Barriers

Although clinical decisions about risk, diagnosis, and treatment selection could be enhanced by considering device-based measures of activity, many barriers prevent incorporation into routine clinical practice. Despite the millions of consumer devices used in daily use, few if any are approved medical devices for activity measurement. Incentives for manufacturers to obtain such approvals are small compared with direct sales as “wellbeing” tools. The accuracy and range of measures provided varies considerably across different devices, with all using different proprietary, and often updated algorithms to process raw accelerometry into features such as “steps”. Wearables capture continuous indoor and outdoor activity data, while mobile phones are carried intermittently, particularly indoors. This makes smartphone-based measures of activity less suitable for people who rarely leave home, such as the elderly or ill. Conversely, only 18% of UK adults have a smartwatch, while 93% use smartphones which are also more equally distributed across income groups[6]. If better healthcare requires wearable ownership this would lead to health inequalities. Decision-support algorithms trained on non-representative data from wearable-owning populations would further entrench inequity[7]. Unlike research data, data used in healthcare must be available at the point of decision-making. This requires an IT infrastructure able to regularly ingest activity data into the patient’s medical record in an interpretable format for clinicians, while being secure from external threats and protecting privacy and data security.

Recommendations

To address these barriers we propose the following steps. Although intuitively useful, evidence to justify introduction of device-based measures of activity in healthcare is limited. Randomised controlled trials are needed that examine the effect of adding information on device-measured physical activity to standard of care, versus standard of care alone, on endpoints including patient satisfaction, clinician confidence, healthcare usage and other outcomes. Should these show benefit, we propose regulators approve devices that successfully fulfil Verification, Analytic Validation, and Clinical Validation assessments[8] for augmentation of clinical decision making, where such decisions are also informed by self-report and clinical assessment. The cost of devices is reducing and may be offset by improved patient outcomes, requiring cost-effectiveness assessment alongside clinical effectiveness studies. Should these prove device-based measurement of activity improves prediction, diagnosis and treatment selection, healthcare systems will have both a responsibility and an incentive to provide devices to those without them.

Conflicts of Interest:

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1. Ekelund U, Tarp J, Steene-Johannessen J, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ* 2019;366:l4570. doi: 10.1136/bmj.l4570
2. Veronese N, Stubbs B, Volpato S, et al. Association Between Gait Speed With Mortality, Cardiovascular Disease and Cancer: A Systematic Review and Meta-analysis of Prospective Cohort Studies. *J Am Med Dir Assoc* 2018;19(11):981-88.e7. doi: 10.1016/j.jamda.2018.06.007 [published Online First: 20180725]
3. Welsh CE, Celis-Morales CA, Ho FK, et al. Grip Strength and Walking Pace and Cardiovascular Disease Risk Prediction in 406,834 UK Biobank Participants. *Mayo Clin Proc* 2020;95(5):879-88. doi: 10.1016/j.mayocp.2019.12.032 [published Online First: 20200413]
4. Stamatakis E, Hamer M, O'Donovan G, et al. A non-exercise testing method for estimating cardiorespiratory fitness: associations with all-cause and cardiovascular mortality in a pooled analysis of eight population-based cohorts. *European Heart Journal* 2012;34(10):750-58. doi: 10.1093/eurheartj/ehs097
5. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;166(1):111-7. doi: 10.1164/ajrccm.166.1.at1102
6. Ofcom. Technology Tracker 2022 [Available from: https://www.ofcom.org.uk/__data/assets/pdf_file/0022/239431/Tech-Tracker-2022-Main-Data-Tables.pdf.
7. Liu X, Cruz Rivera S, Moher D, et al. Reporting guidelines for clinical trial reports for interventions involving artificial intelligence: the CONSORT-AI extension. *Nat Med* 2020;26(9):1364-74. doi: 10.1038/s41591-020-1034-x [published Online First: 20200909]
8. Goldsack JC, Coravos A, Bakker JP, et al. Verification, analytical validation, and clinical validation (V3): the foundation of determining fit-for-purpose for Biometric Monitoring Technologies (BioMeTs). *npj Digital Medicine* 2020;3(1):55. doi: 10.1038/s41746-020-0260-4