TITLE

Emerging collaborative research platforms for the next generation of physical activity, sleep and exercise medicine guidelines: the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS)

AUTHOR AND AFFILIATIONS:

Emmanuel Stamatakis[1], Annemarie Koster[2], Mark Hamer[3], Vegar Rangul[4], I-Min Lee[5], Adrian Bauman[1], Andrew J Atkin[6], Mette Aadahl[7], Charles E. Matthews[8], Paul Jarle Mork[9], Lisa Askie[10], Peter A. Cistulli[11], Malcom Granat[12], Peter Palm[13], Patrick Crowley[14], Matthew Stevens[14], Nidhi Gupta[14], Anna Pulakka[15], Sari Stenholm[15], Daniel Arvidsson[16], Gita Mishra[17], Patrik Wennberg[18], Sebastien Chastin[19], Ulf Ekelund[20], and Andreas Holtermann[14]

[1] Prevention Research Collaboration, Charles Perkins Centre, Faculty of Medicine and Health, School of Public Health, University of Sydney, Australia
[2] Department of Social Medicine, CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands.
[3] School Sport Exercise Health Sciences, Loughborough University, UK
[4] HUNT Research Centre, Department of Public Health and Nursing, Norwegian University of Science and Technology, Levanger, Norway
[5] Division of Preventive Medicine, Brigham & Women's Hospital and Harvard Medical School, Boston, MA, USA
[6] School of Health Sciences, Faculty of Medicine and Health Sciences, University of East Anglia, Norwich, UK.
[7] Centre for Clinical Research and Prevention, Bispebjerg and Frederiksberg Hospital, Frederiksberg, Denmark.
[8] Metabolic Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Rockville, MD USA
[9] Department of Public Health and Nursing, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
[10] NHMRC Clinical Trials Centre, University of Sydney, Australia
[11] Sleep Research Group, Charles Perkins Centre, Faculty of Medicine and Health, University of Sydney, Australia.
[12] School of Health and Society Sciences, University of Salford, Salford, UK
[13] Department of Medical Sciences, Occupational and Environmental Medicine, Uppsala University, Sweden
[14] The National Research Centre for the Working Work Environment, Copenhagen, Denmark

[15] Department of Public Health, University of Turku and Turku University Hospital, Turku, Finland

[16] Center for Health and Performance, Department of Food and Nutrition and Sport Science, University of Gothenburg, Sweden

[17] School of Public Health, University of Queensland, Brisbane, Australia.

[18]Department of Public Health and Clinical Medicine, Family Medicine, Umeå University, Sweden

[19] School of Health and Life Science, Glasgow Caledonian University, Glasgow, Scotland, UK

[20] Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway

CORRESPONDING AUTHOR

Emmanuel Stamatakis, 6th floor West, The Hub, Charles Perkins Centre, Building D17,

University of Sydney, Camperdown, NSW 2006, Australia

email: emmanuel.stamatakis@sydney.edu.au   T: +61 2 86271867

904 words

TEXT

Galileo Galilei's quote "*measure what is measurable, and make measurable what is not so*" has particular relevance to health behaviours, such as physical activity (PA), sitting and sleep, whose measurement during free living is notoriously difficult. To date, much of what we know about how these behaviours affect our health is based on self-report by questionnaires which have limited validity, are prone to bias, and inquire about selective aspects of these behaviours. Although self-reported evidence has made great contributions to shaping public health and exercise medicine policy and guidelines until now[1], the ongoing advancements of accelerometry-based measurement and evidence synthesis methods are set to change the landscape. The aim of this editorial is to outline new directions in PA and sleep related epidemiology that open new horizons for guideline development and improvement; and to describe a new research collaboration platform: the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS).

Feasible research technology at scale, big consortia

Measurement technology used in epidemiology has made measurable what *was not so* until recently. Several population-based studies have used accelerometers to wear for 24 hours a day for a whole week, offering unprecedented insights into the health attributes of PA, sitting and sleep. One of the most exciting aspect of accelerometers is that they show great promise for capturing *nearly-complete* accounts PA, including posture and activity type detection[2].

However, advanced measurement methods and optimal evidence synthesis are not synonymous. Individual accelerometry studies have limited generalisability beyond the specific country, population, and setting, and usually have low statistical power to address detailed research questions. For example, none of the NHANES accelerometry studies[3] has been able to study potentially metabolic health-enhancing sporadic short (<2-3 minutes) bursts of higher intensity incidental PA[4], likely because of the sparsity of such data. Classic systematic reviews of accelerometry inherit the problems of source studies and their conclusions are often not robust[5]. We need to think differently when it comes to consolidating, analysing, and interpreting new formats of accelerometry data. As John Ioannidis' BJSM editorial succinctly put it, the next generation of evidence in exercise medicine and PA involves large consortia that harmonise and pool existing studies.[5] Prospective harmonisation (i.e. agree on same or similar measurements across different

studies prior to data collection), in particular, is an extremely powerful tool as it can overcome heterogeneity, which is one of the largest obstacles for rigorous evidence synthesis[5]. The value of such consortia goes beyond producing more robust and generalisable knowledge, there is also a strong economic argument. The value of every dollar, pound, or euro tax payers and research funders invested in the original studies is maximised through further use of the data resources to inform better public health and clinical practice guidelines.

A new consortium

The momentum generated by successful accelerometry consortia (e.g. International Children's Accelerometry Database[6]) and large epidemiological studies like NHANES[3] and the UK Biobank[7] that used waist or wrist mounted accelerometers inspired the genesis of the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS)[8]. ProPASS is a research collaboration platform that aims to bring together existing and future observational studies of thigh-worn accelerometry. Although each accelerometer placement site has both strengths and challenges, the ProPASS choice of site was far from accidental: the unique appeal of the thigh-worn method is that it provides information not only on movement intensity (e.g. light, moderate and vigorous PA), but also on posture (e.g. sitting/lying, standing). Behaviours such as cycling, running, and stair-climbing can also be extrapolated by thigh attached sensors[2] and integration with other important behaviours such as sleep (duration and timing) can provide unique insights on lifestyle and health[9]. Information about such tangible aspects of behaviour has immediate relevance to people's daily lives; and is easier for clinicians, policy makers, and the public alike to understand, "digest", and hopefully seek to improve.

The ultimate scientific objective of ProPASS is to produce evidence on the associations of PA, sitting, and sleep and long-term health outcomes and longevity. As of February 2019, ProPASS is supported by twelve international cohorts totalling over 70,000 participants (Table 1). To safeguard consortium feasibility, longevity and faster growth, ProPASS is not restricted to one specific model of accelerometer, but any tri-axial device that outputs raw acceleration and is worn on the thigh is suitable- an approach we have validated empirically[10]. The ProPASS cohorts are rich in health outcome data, many contain genotypic information, and most can be linked to administrative health and mortality records, opening up a huge variety of possibilities for generation of new knowledge.

Call for collaboration

New research collaboration platforms have paved the way for the next generation of evidence on PA-related behaviours and health. Detailed and accurate objective accounts of daily movement behaviour and posture are now feasible in large epidemiological studies. Meeting ProPASS' objectives will be determined by at least two essential conditions: breaking down the silos to integrate research paradigms across PA domains; and tight multidisciplinary collaboration.

In this editorial we invite researchers from any discipline who have collected or are considering collecting thigh-worn accelerometry data in observational studies to contact us. We also invite, scientists with an interest in health related data consortia as well as health professionals and policy makers, to help us form a ProPASS research agenda with maximal relevance to patients, the public, and health policy. There is no question in our mind that such a research agenda is a prerequisite for the success of ProPASS and any other effort aimed at shaping the next generation of physical activity, sitting, sleep, and exercise medicine guidelines.

Get in touch to discuss opportunities for current or future studies joining the consortium (e-mail: propass.consortium@sydney.edu.au), and join our mailing list (www.propassconsortium.org) to stay updated about future events and activities.

;

REFERENCES

1. 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: U.S. Department of Health and Human Services, 2018.
2. Skotte J, Korshoj M, Kristiansen J, et al. Detection of physical activity types using triaxial accelerometers. *Journal of physical activity & health* 2014;11(1):76-84. doi: 10.1123/jpah.2011-0347 [published Online First: 2012/12/20]
3. Fuzeki E, Engeroff T, Banzer W. Health Benefits of Light-Intensity Physical Activity: A Systematic Review of Accelerometer Data of the National Health and Nutrition Examination Survey (NHANES). *Sports medicine (Auckland, NZ)* 2017;47(9):1769-93. doi: 10.1007/s40279-017-0724-0 [published Online First: 2017/04/11]
4. Stamatakis E, Johnson NA, Powell L, et al. Short and sporadic bouts in the 2018 US physical activity guidelines: is high-intensity incidental physical activity the new HIIT? *British Journal of Sports Medicine* 2019:bjsports-2018-100397. doi: 10.1136/bjsports-2018-100397
5. Ioannidis J. Next-generation systematic reviews: prospective meta-analysis, individual-level data, networks and umbrella reviews. *British Journal of Sports Medicine* 2017;51(20):1456-58. doi: 10.1136/bjsports-2017-097621
6. Sherar LB, Griew P, Esliger DW, et al. International children's accelerometry database (ICAD): design and methods. *BMC public health* 2011;11:485. doi: 10.1186/1471-2458-11-485 [published Online First: 2011/06/23]
7. Doherty A, Smith-Byrne K, Ferreira T, et al. GWAS identifies 14 loci for device-measured physical activity and sleep duration. *Nature communications* 2018;9(1):5257. doi: 10.1038/s41467-018-07743-4 [published Online First: 2018/12/12]
8. ProPASS consortium. Prospective Physical Activity, Sitting, and Sleep cosnsortium 2019 [Available from: www.propassconsortium.org.
9. van der Berg JD, Willems PJ, van der Velde JH, et al. Identifying waking time in 24-h accelerometry data in adults using an automated algorithm. *Journal of sports sciences* 2016;34(19):1867-73. doi: 10.1080/02640414.2016.1140908 [published Online First: 2016/02/04]
10. Crowley P, Skotte J, Stamatakis E, et al. Comparability of the physical activity and posture output of different thigh worn accelerometers: A proof of concept of the Prospective Physical Activity, Sitting, and Sleep consortium. Under review

Table 1: Accelerometry studies supporting the Prospective Physical Activity, Sitting, and Sleep consortium (ProPASS)

Main Study Name / Country	Leading Institution	Geographical Coverage of the Study	Number of Participants (n)	Sex	Population /Age Range (accelerometry measurement)	Accelerometry Device	Years (accelerometry measurement)
Australian Longitudinal Study for Women's Health / Australia	The University of Queensland and The University of Sydney	Australia	(target) ≈ 3,250	Women	General population / 45-50 years	ActivPAL3 and ActivPAL4 micro	2019-20
1970 British Birth Cohort Study / UK	Loughborough University and University College London	UK	≈ 5,500	Both	General population / 47-49 years	ActivPAL3 micro	2016-18
Copenhagen City Heart Study / Denmark [3]	Copenhagen City Heart Study, Frederiksberg Hospital, Copenhagen	Two districts of Copenhagen	≈ 2,000	Both	General Population /18 years or older	Actigraph GT3X	2011-2015
Danish PHysical ACTivity cohort with Objective measurements (DPHACTO) Study [4] / Denmark	National Research Centre for the Working Environment, Copenhagen	Denmark	≈ 1,000	Both	Workers in manufacturing, cleaning and transportation companies / 18-67 years	Actigraph GT3X	2012-2014
Danish Observational Study of Eldercare work and musculoskeletal disorderS (DOSES)[5] Study/ Denmark	National Research Centre for the Working Environment, Copenhagen	Greater Copenhagen region	≈ 500	Both	Eldercare workers / 18 to 67 years of age	Actigraph GT3X	2013-2014
Finnish Retirement and Aging Study (FIREA) / Finland[6]	University of Turku	Southwest Finland	≈ 280	Both	General Population /Occupational cohort / 59-65 60-64	ActivPAL3	2015-2020
Health2016 Study / Denmark	Centre for Clinical Research and Prevention, Frederiksberg	Western part of Greater Copenhagen	≈800	Both	General Population / 18-69	Axivity	2016-2017

The Nord-Trøndelag Health Study (HUNT 4) [7] / Norway	Norwegian University of Science and Technology	Northern part of Trøndelag region	≈ 40,000	Both	General Population / 18 years or older	Axivity 3	2017-19
The Maastricht Study [8] / The Netherlands	Maastricht University	South of The Netherlands	≈ 9,000	Both	General Population (Oversampling of people with Type 2 Diabetes) / 40-75	ActivPAL3	2010-2019
Swedish CArdioPulmonary bioImage Study (SCAPIS) [9] Ad-On Gothenburg / Sweden	University of Gothenburg	Gothenburg region	≈ 500	Both	General Population / 50-64	Axivity AX3	2017
Swedish CArdioPulmonary bioImage Study (SCAPIS) [9] Ad-On Umeå / Sweden	Umeå University	Umeå region	≈ 2,500	Both	General Population / 50-64	ActivPAL3	2016-2018
Swedish CArdioPulmonary bioImage Study Ad- On Uppsala (SCAPIS) [9] / Sweden	Uppsala University	Uppsala region	≈ 5,000	Both	General Population / 50-64	Axivity AX3	2015-2018

1 McLaughlin D, et al. (2015) Cohort Profile Update: Australian Longitudinal Study on Women's Health. International Journal of Epidemiology 44, 1547-1547f.

2 Elliott J, Shepherd P (2006) Cohort Profile: 1970 British Birth Cohort (BCS70). International Journal of Epidemiology 35, 836-843.

3 Aguib Y, Al Suwaidi J. The Copenhagen City Heart Study (Østerbroundersøgelsen). Global Cardiology Science & Practice 2015; 2015: 33-.

4 Jørgensen MB, et al. The DPhacto cohort: An overview of technically measured physical activity at work and leisure in blue-collar sectors for practitioners and researchers. Applied Ergonomics, 2019. 77, 29-39.

5 Karstad K, et al . Danish Observational Study of Eldercare work and musculoskeletal disorderS (DOSES): a prospective study at 20 nursing homes in Denmark. BMJ Open. 2018 Feb 28;8(2):e019670.

6 Pulakka A, Leskinen T, Koster A et al. (2019) Daily physical activity pattern among aging workers: the Finnish Retirement and Aging Study (FIREA). Occupational & Environmental Medicine 76, 33-39

7 Krokstad S, et al. (2013) Cohort Profile: the HUNT Study, Norway. Int J Epidemiol 42, 968-977.

8 Schram MT, et al. (2014) The Maastricht Study: an extensive phenotyping study on determinants of type 2 diabetes, its complications and its comorbidities. European Journal of Epidemiology 29, 439-451.

9 Bergström G, et al. (2015) The Swedish CArdioPulmonary BioImage Study: objectives and design. Journal of Internal Medicine 278, 645-659.