

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)

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) (figure 1).



Figure 1

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 use accelerometers that are worn by participants 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 aspects of accelerometers is that they show great promise for capturing *nearly complete* accounts of movement behaviour, 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 National Health and Nutrition Examination Survey (NHANES) accelerometry studies³ have been able to study potentially metabolic health-enhancing sporadic short (<2–3 min) bursts of higher intensity incidental PA,⁴ likely because of the sparsity of such data. Like any other field, classic systematic reviews of accelerometry inherit the problems of source studies and their conclusions may not be 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 of individual participant data that are harmonised retrospectively or prospectively.⁵ Prospective harmonisation (ie, 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 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 multiplied 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 (eg, International Children's Accelerometry Database⁶) and large epidemiological studies like NHANES³ and the UK Biobank⁶ that used waist or wrist mounted accelerometers inspired the genesis of the ProPASS.⁷ 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 on multiple dimensions of movement behaviour, including movement intensity (eg, light, moderate and vigorous PA) and posture (eg, sitting/lying, standing). Activity types such as cycling, running and stair climbing can also be extrapolated by thigh-attached sensors² and integration with other important behaviours such as duration and timing of sleep can provide unique insights on lifestyle and health.⁸ Information about such tangible aspects of human behaviour has immediate relevance to people's daily lives; and is easier for clinicians, policymakers 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 12 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; any triaxial device that outputs raw acceleration and is worn on the thigh is suitable—an approach we have validated empirically.⁹ 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 to generate new knowledge.

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	Participants (n)	Sex	Population/age range (accelerometry measurement)	Accelerometry device	Years (accelerometry measurement)
Australian Longitudinal Study on Women's Health/ Australia	The University of Queensland and The University of Sydney	Australia	(target) ≈3250	Women	General population/45–50 years	ActivPAL3 and ActivPAL4 micro	2019–2020
1970 British Birth Cohort Study/UK	Loughborough University and University College London	UK	≈5500	Both	General population/47–49 years	ActivPAL3 micro	2016–2018
Copenhagen City Heart Study/Denmark ¹⁰	Frederiksberg Hospital, Copenhagen	Two districts of Copenhagen	≈2000	Both	General population/18 years or older	Actigraph GT3X	2011–2015
Danish Physical Activity cohort with Objective measurements (DPHACTO) Study ¹¹ /Denmark	National Research Centre for the Working Environment, Copenhagen	Denmark	≈1000	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) ¹² Study/Denmark	National Research Centre for the Working Environment, Copenhagen	Greater Copenhagen region	≈500	Both	Eldercare workers/18–67 years	Actigraph GT3X	2013–2014
Finnish Retirement and Aging Study (FIREA)/ Finland ¹³	University of Turku	Southwest Finland	≈280	Both	General population/ occupational cohort/59–65 years, 60–64 years	ActivPAL3	2015–2020
Health 2016 Study/Denmark	Centre for Clinical Research and Prevention, Frederiksberg	Western part of Greater Copenhagen	≈800	Both	General population/18–69 years	Axivity	2016–2017
The Nord-Trøndelag Health Study (HUNT 4) ¹⁴ /Norway	Norwegian University of Science and Technology	Northern part of Trøndelag region	≈40 000	Both	General population/18 years or older	Axivity 3	2017–2019
The Maastricht Study ¹⁵ /The Netherlands	Maastricht University	South of The Netherlands	≈9000	Both	General population (oversampling of people with type 2 diabetes)/40–75 years	ActivPAL3	2010–2019
Swedish CardioPulmonary bioImage Study (SCAPIS) ¹⁶ Ad-On Gothenburg/Sweden	University of Gothenburg	Gothenburg region	≈500	Both	General population/50–64 years	Axivity AX3	2017
Swedish CardioPulmonary bioImage Study (SCAPIS) ¹⁶ Ad-On Umeå/Sweden	Umeå University	Umeå region	≈2500	Both	General population/50–64 years	ActivPAL3	2016–2018
Swedish CardioPulmonary bioImage Study (SCAPIS) Ad-On Uppsala ¹⁶ /Sweden	Uppsala University	Uppsala region	≈5000	Both	General population/50–64 years	Axivity AX3	2015–2018

CALL FOR COLLABORATION

New research collaboration platforms have paved the way for the next generation of evidence on PA-related behaviours and health. Recording detailed and accurate objective accounts of daily movement behaviour and posture is now feasible in large epidemiological studies. To fully capitalise on the opportunities offered by such methodological progress at least two essential conditions need to be met: breaking down silos to integrate research paradigms across PA domains, and tight interdisciplinary collaboration. Meeting ProPASS' objectives is dependent on these conditions.

In this editorial we invite researchers from any discipline who have collected or are considering to collect 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 policymakers 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 PA, sitting, sleep and exercise medicine guidelines.

Get in touch to discuss opportunities for your existing or future studies to join ProPASS (email: propass.consortium@sydney.edu.au). Join our mailing list (www.propassconsortium.org) to stay updated about future events and activities.

Emmanuel Stamatakis,⁰¹ Annemarie Koster,⁰² Mark Hamer,^{03,4} Vegar Rangul,⁰⁵ I-Min Lee,⁰⁶ Adrian E Bauman,^{01,7} Andrew J Atkin,⁰⁸ Mette Aadahl,⁰⁹ Charles E Matthews,¹⁰ Paul Jarle Mork,¹¹ Lisa Askie,¹² Peter Cistulli,¹³ Malcolm Granat,¹⁴ Peter Palm,¹⁵ Patrick Joseph Crowley,¹⁶ Matthew Stevens,¹⁶ Nidhi Gupta,¹⁶ Anna Pulakka,¹⁷ Sari Stenholm,¹⁷ Daniel Arvidsson,¹⁸ Gita Mishra,¹⁹ Patrik Wennberg,⁰⁹

²⁰ Sebastien Chastin,^{21,22} Ulf Ekelund,²³ Andreas Holtermann¹⁶

¹Prevention Research Collaboration, Charles Perkins Centre, Faculty of Medicine and Health, School of Public Health, University of Sydney, Sydney, New South Wales, Australia

²Department of Social Medicine, CAPHRI Care and Public Health Research Institute, Maastricht University, Maastricht, The Netherlands

³Department of Epidemiology and Public Health, University College London, London, UK

⁴School of Sport Exercise and Health Sciences, Loughborough University, Loughborough, UK

⁵Department of Public Health and Nursing, HUNT Research Centre, Norwegian University of Science and Technology, Trondheim, Norway

⁶Division of Preventive Medicine, Brigham and Women's Hospital and Harvard Medical School, Harvard University, Cambridge, Massachusetts, USA

⁷Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

⁸Faculty of Medicine and Health Sciences, School of Health Sciences, University of East Anglia, Norwich, UK

⁹Research Centre for Prevention and Health, Copenhagen, Denmark

¹⁰Metabolic Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, Maryland, USA

¹¹Department of Public Health and Nursing, The Norwegian University of Science and Technology, Trondheim, Norway

¹²NHMRC Clinical Trials Centre, University of Sydney, Sydney, New South Wales, Australia

¹³Sleep Research Group, Charles Perkins Centre, Faculty of Medicine and Health, University of Sydney, Sydney, New South Wales, Australia

¹⁴School of Health Sciences, University of Salford, Salford, UK

¹⁵Occupational and Environmental Medicine, Department of Medical Sciences, Uppsala Universitet, Uppsala, Sweden

¹⁶National Research Centre for the Working Environment, Copenhagen, Denmark

¹⁷Department of Public Health, University of Turku, Turku, Finland

¹⁸Department of Food and Nutrition and Sport Science, Centre for Health and Performance, University of Gothenburg, Gothenburg, Sweden

¹⁹School of Public Health, University of Queensland, Brisbane, Queensland, Australia

²⁰Family Medicine, Department of Public Health and Clinical Medicine, Umea University, Umea, Sweden

²¹School of Health and Life Science, Institute for Applied Health Research, Glasgow Caledonian University, Glasgow, UK

²²Department of Movement and Sports Sciences, Universiteit Gent, Gent, Belgium

²³Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway

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REFERENCES

- 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.
- Skotte J, Korshøj M, Kristiansen J, *et al.* Detection of physical activity types using triaxial accelerometers. *J Phys Act Health* 2014;11:76–84.
- Füzéki 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 Med* 2017;47:1769–93.
- 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 HIT? *Br J Sports Med* 2019.
- Ioannidis J. Next-generation systematic reviews: prospective meta-analysis, individual-level data, networks and umbrella reviews. *Br J Sports Med* 2017;51:1456–8.
- Doherty A, Smith-Byrne K, Ferreira T, *et al.* GWAS identifies 14 loci for device-measured physical activity and sleep duration. *Nat Commun* 2018;9.
- ProPASS consortium. Prospective physical activity, sitting, and sleep consortium, 2019. Available: www.propassconsortium.org
- van der Berg JD, Willems PJB, van der Velde JHPM, *et al.* Identifying waking time in 24-h accelerometry data in adults using an automated algorithm. *Journal of Sports Sciences* 2016;34:1867–73.
- Crowley P, Skotte J, Stamatakis E, *et al.* A comparison of movement behavior estimates from three different thigh-worn accelerometer models: a proof-of-concept for the ProspectivePhysical Activity, Sitting, and Sleep consortium (ProPASS). Under review.
- Aguib Y, Al Suwaidi J. The Copenhagen City Heart study (Østerbrounderundersøgelsen). *Global Cardiology Science and Practice* 2015;2015.
- Jørgensen MB, Gupta N, Korshøj M, *et al.* The DPhacto cohort: an overview of technically measured physical activity at work and leisure in blue-collar sectors for practitioners and researchers. *Appl Ergon* 2019;77:29–39.
- Karstad K, Jørgensen AFB, Greiner BA, *et al.* Danish observational study of eldercare work and musculoskeletal disorderS (doses): a prospective study at 20 nursing homes in Denmark. *BMJ Open* 2018;8:e019670.
- Pulakka A, Leskinen T, Koster A, *et al.* Daily physical activity patterns among aging workers: the Finnish retirement and aging study (FIREA). *Occup Environ Med* 2019;76:33–9.
- Krokstad S, Langhammer A, Hveem K, *et al.* Cohort profile: the HUNT study, Norway. *Int J Epidemiol* 2013;42:968–77.
- Schram MT, Sep SJS, van der Kallen CJ, *et al.* The Maastricht study: an extensive phenotyping study on determinants of type 2 diabetes, its complications and its comorbidities. *Eur J Epidemiol* 2014;29:439–51.
- Bergström G, Berglund G, Blomberg G, , , , *et al.* The Swedish cardiopulmonary Biolmage study: objectives and design. *Journal of Internal Medicine* 2015;278:645–59.
- Sherar LB, Griev P, Esliger DW, *et al.* International children's accelerometry database (ICAD): design and methods. *BMC Public Health* 2011;11.
- Dobson AJ, Hockey R, Brown WJ, McLaughlin D, *et al.* Cohort profile update: Australian longitudinal study on women's health. *Int J Epidemiol* 2015;44:1547–1547f.
- Elliott J, Shepherd P. Cohort profile: 1970 British birth cohort (BCS70). *Int J Epidemiol* 2006;35:836–43.