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Review

Considerations when using the activPAL monitor in field-based research with adult populations

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Abstract

Research indicates that high levels of sedentary behavior (sitting or lying with low energy expenditure) are adversely associated with health. A key factor in improving our understanding of the impact of sedentary behavior (and patterns of sedentary time accumulation) on health is the use of objective measurement tools that collect date and time-stamped activity information. One such tool is the activPAL monitor. This thigh-worn device uses accelerometer-derived information about thigh position to determine the start and end of each period spent sitting/lying, standing, and stepping, as well as stepping speed, step counts, and postural transitions. The activPAL is increasingly being used within field-based research for its ability to measure sitting/lying via posture. We summarise key issues to consider when using the activPAL in physical activity and sedentary behavior field-based research with adult populations. It is intended that the findings and discussion points be informative for researchers who are currently using activPAL monitors or are intending to use them. Pre-data collection decisions, monitor preparation and distribution, data collection considerations, and manual and automated data processing possibilities are presented using examples from current literature and experiences from 2 research groups from the UK and Australia.
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1. Introduction

Over the past decade, there has been substantial, and growing, scientific interest in sedentary behavior.[1–3] In 2012, an expert consensus defined sedentary behavior as "any waking activity characterised by an energy expenditure ≤1.5 metabolic equivalents and a sitting or reclining posture".[4] It is now recognised that sedentary behavior is common (on average adults spend 46%–73% of waking hours sedentary),[5–10] and that too much time spent sedentary may be detrimental to health both in the short term[11–14] and long term.[3,15–17]

The availability of objective measurement tools with date and time-stamped information about activity is a key factor in improving our understanding of the impact of sedentary behavior and patterns of sedentary time accumulation on health. Most of the evidence on the associations of objectively assessed sedentary time and health has been derived from tools that infer sedentary time from a lack of movement.[8,10,18–20] However, this can lead to misclassification of low-intensity non-sedentary behaviors as sedentary behaviors.[21] A key example of this is standing. Like sitting or lying, standing involves minimal movement and low energy expenditure.[22] However, unlike sitting or lying, this behavior is characterised by its upright posture which elicits higher muscle contractile activity[23] with associated beneficial impacts on physiological processes such as glucose metabolism.[11,13–24]

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Notably, while the 2012 definition of sedentary behavior includes both energy expenditure and postural elements,[4] no field-based tool as yet directly and accurately captures both of these elements. The thigh-mounted activPAL monitor (activPAL™, activPAL3™, and activPAL3™ micro; PAL Technologies Ltd., Glasgow, UK) is 1 measurement device that directly measures the postural aspect of sedentary behavior. The activPAL device (referring to all models) is a small and slim thigh-worn monitor. Via proprietary algorithms (Intelligent Activity Classification), accelerometer-derived information about thigh position and acceleration are used to determine body posture (i.e., sitting/lying and upright) and transition between these postures, stepping, and stepping speed (cadence), from which energy expenditure is inferred indirectly. The activPAL has almost perfect correlation and excellent agreement with direct observation for sitting/lying time, upright time, sitting/lying to upright transitions and for detecting reductions in sitting.[21,25–27] Additionally, it accurately distinguishes standing from stepping[26] and identifying stepping speed (cadence);[28] however, accuracy for detecting stepping is compromised at very slow (i.e., <0.5 m/s) walking speeds.[29] As such, the use of the activPAL device in physical activity and sedentary behavior research has increased rapidly in recent years (460% increase from 2008 to 2014 on the Scopus citation database).

With the increasing use of activPAL monitors to address important questions in sedentary behavior research, it is timely to consider some of the methodological and practical considerations specific to these monitors. Existing best practice recommendations for objective activity monitoring, such as those outlined by Matthews et al.,[30] provide an excellent starting point. However, these are either general, or focused on other monitors that have key differences to activPAL devices, from the method and location of attachment, to the properties of the resultant data. Accordingly, some existing recommendations may not be applicable, and the unique opportunities and challenges specific to activPAL monitors warrant consideration and further elucidation.

This report provides an overview of the key data collection and processing issues to consider when using the activPAL activity monitor in physical activity and sedentary behavior field-based research with adult populations. The considerations discussed are categorised under: pre-data collection, monitor preparation and distribution, data collection, data processing, and data reporting. The considerations are mainly based on the procedures and protocols reported in the current literature (free-living adult studies identified from the PAL Technologies' bibliography (September 2014) and by searching the term "activPAL" in PubMed (October 2015)). Only those accessible in full-text form were included (Table 1). However, given the paucity of detail in the published literature, we also based considerations on the experiences from 2 international research groups (Table 2). These experiences span across both epidemiological and intervention study designs, various adult population groups and settings. It is intended that these findings and discussion points be informative for researchers who are both currently using activPAL monitors or are intending to use such devices. It is not intended that the practices employed to date should be taken as best practice for the field.

2. Pre-data collection considerations

2.1. Wear period: number of days of monitoring

The number of days of monitoring ideally depends on the study design and purpose. The majority of studies (71%) that we considered in the literature (Table 1) and those in Table 2 have asked participants to wear the activPAL for 7 full days. To our knowledge only 1 study has reported how many days of monitoring are required to provide adequate reliability for several activPAL outputs (sitting, standing, stepping, and transitions) in adults.[31] Applying the Spearman–Brown Prediction Formula,[32] Reid et al.[31] showed to achieve intra-class correlations (ICCs) of 0.8 and 0.9, respectively, 5 days and 11 days respectively were needed for sitting, 5 days and 10 days respectively for standing, and 7 days and 15 days respectively for stepping in a population of older adults living in residential care. However, this approach has limitations, as each day is treated as randomly sampled (but they consecutive) and no distinction is made between particular days of the week. In reality, mean activity levels and correlations are likely to vary by day of the week.[33]

More recently, generalisability theory has been applied to investigate the reliability of activPAL measured sitting time and moderate-to-vigorous physical activity (MVPA).[34] Generalisability theory gives a better indication of repeatability than the ICCs, particularly when more sources of variation, including seasonality, are considered.[35] Barreira et al.[34] showed that in women, to achieve G-coefficients (interpreted identically to an intra-ICC value) of 0.8 and 0.9, respectively, 4 and 9 wear days were needed for sitting and 7 and 21 wear days were needed for MVPA. Achieving an acceptable degree of repeatability, whether by ICC or G-coefficients, indicates that within-individual variation is low in proportional to other sources of variation. The number of days required to achieve a particular ICC or G-coefficient relates to both properties of the measure and the population, and therefore should be reported for a wider range of outputs and populations using up-to-date methods.

From a practical perspective, researchers are also limited by the 16 MB (32 MB for activPAL3 micro) memory capacity of the activPAL3 monitor, which with a sampling frequency of 20 Hz (80 Hz available in research mode) allows up to 14 days of monitoring. The activPAL3 micro has a larger memory capacity, yet still only allows for up to 14 days of monitoring. Pending better recommendations, for a single assessment, studies should use a protocol that is at least 7 days and ideally up to the 14 days limitation of the monitor. This recommendation takes into consideration that the number of days requirements are largely unknown, but at times exceed 7 days. Multiple assessments, including covering multiple seasons, have been shown to improve reliability and better estimate long-term activity over single-season assessments.[35]

2.2. Wear period: time of wear

In studies where the wear protocol was clear (Table 1, 38/55 studies), 32% asked participants to wear the monitor during

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