



## The validity and reliability of consumer-grade activity trackers in older, community-dwelling adults: A systematic review



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### ABSTRACT

**Objective:** To understand the validity and reliability of consumer-grade activity trackers (consumer wearables) in older, community-dwelling adults.

**Methods:** A systematic review of studies involving adults aged over 65 years who underwent physical activity monitoring with consumer wearables. A total of 7 observational studies qualified, identified from electronic databases: MEDLINE, EMBASE, Cochrane Library and others (2014–2018). Validity was interpreted using correlation coefficients (CC) and percentage error for agreement between reference devices or gold-standard validation methods. Reliability was compared using mean differences or ranges (under- or overestimation) of step count and activity time.

**Results:** Total sample size was 290 adults, mean age of  $70.2 \pm 4.8$  years and females constituting  $46.7 \pm 26.1\%$ . The studies evaluated eight different consumer wearables used by community-dwelling adults with a range of co-morbidities. Daily step count for all consumer wearables correlated highly with validation criterion, especially the ActiGraph device: intraclass correlation coefficients (ICC) were 0.94 for Fitbit One, 0.94 for Zip, 0.86 for Charge HR and 0.96 for Misfit Shine. Slower walking pace and impaired ambulation reduced the levels of agreement. Daily step count captured by Fitbit Zip was on average 7117 ( $\pm 5,880.6$ ), which was overestimated by five of the eight consumer wearables compared with reference devices (range 167.6–2,690.3 steps/day). Measurement of activity duration was accurate compared with reference devices, yet less so than step count.

**Conclusion:** In older, community-dwelling adults, consumer wearables accurately measure step count and activity duration, as confirmed by reference devices and validation methods. Further research is required to understand how co-morbidities, gait and activity levels interact with monitoring in free-living environments.

### 1. Introduction

Healthy ageing has evolved from simply a desire to increase life expectancy, to more aspirational aims of avoiding disease, preserving physical functioning and allowing an independent engagement with life. Compelling evidence from meta-analyses and Cochrane reviews demonstrate the benefits of exercise, especially when physical activity (PA) is planned, structured and underpinned by the goal to improve or maintain physical fitness, performance and health for elderly people [1]. Exercise benefits for older people not only include prevention and

treatment of increasingly prevalent chronic conditions, such as cardiovascular disease, but often more importantly, improvements in health-related quality of life [2]. The World Health Organisation [3] recommends a minimum average daily activity of 30 min at moderate-intensity, which can be achieved through walking (steps) and walking rapidly or uphill (steps/time). Free-living PA can be defined as a person's everyday physical activity in their usual environment, and for older, community-dwelling adults it is free-living PA which is crucial. The aims of PA in older people are to reduce sedentary behaviour, increase autonomy in daily activities and sustain long-term exercise goals,

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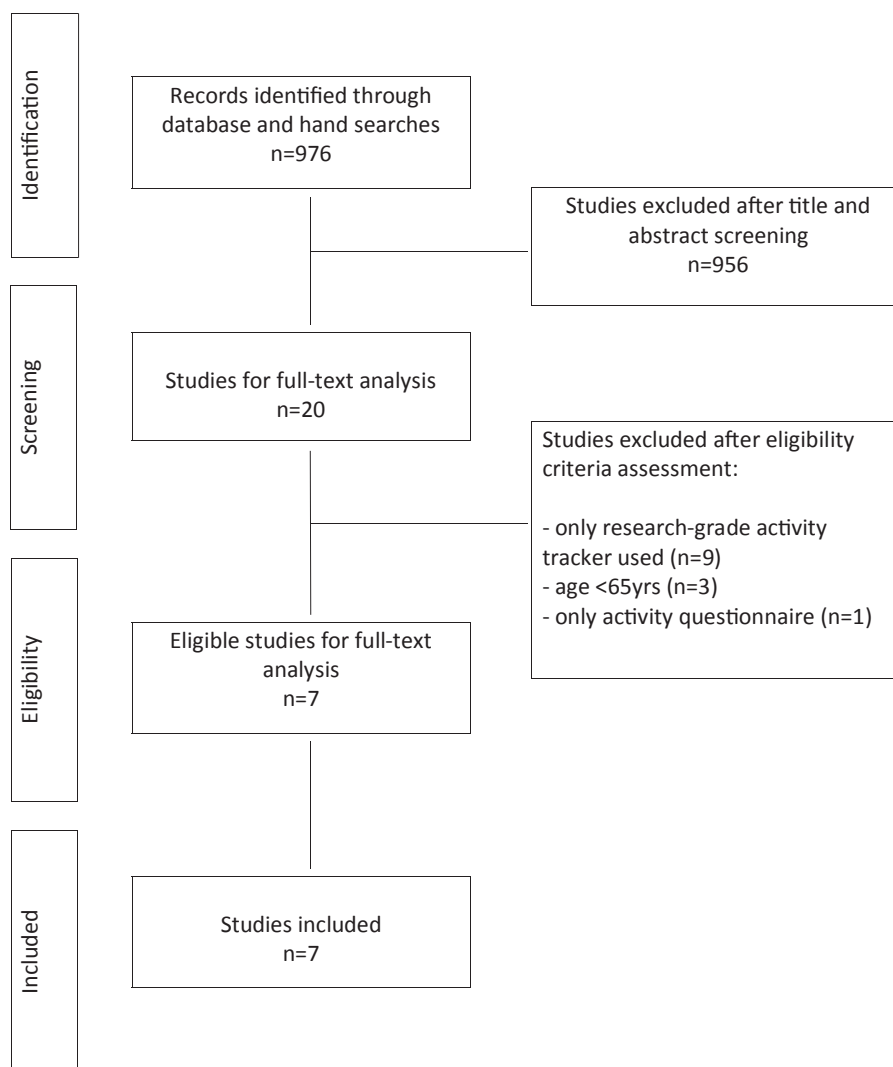


Fig. 1. Search Strategy.

and as such these objectives are recommended to be achieved in older people's normal surroundings [4].

Contemporary technology provides an unprecedented opportunity for the use of consumer-grade activity trackers (consumer wearables) to both understand, investigate and promote sustainable PA in older people. The measurement of PA is essential to all of these aims. The mainstay of measurement in older people has been self-report, and less often through the use of research-grade activity trackers. Self-report has inherent limitations, including the need to monitor duration and type of PA is being undertaken, as well as the capacity to recall specific aspects [5]. Often both these necessary attributes are flawed, leading to over-estimation. Furthermore, self-report questionnaires have been criticised for the tendency to be age- or disease biased, excluding common elements of regular physical activity (e.g. personal care or domestic tasks), both potentially creating restrictions in accurate responses from older people. In contrast, research-grade motion sensors, which monitor activity such as pedometers, actometers and accelerometers, circumvent these issues by direct tracking [6]. Whilst these measurement devices are validated, they are often cumbersome and difficult to apply, therefore less useful in long-term monitoring of everyday PA in older, community-dwelling adults, for either research requirements or personal motivation. Consequently, within the array of trackers, it is the consumer-grade physical activity trackers (e.g. Fitbit™, Polar™, Garmin™, Apple Watch Sport™), which may become the preferred self-monitoring, measurement option. Many studies to date have sought to

validate the growing range of consumer-grade activity trackers, in both 'controlled' laboratory and 'free-living' environments [7,8], and with healthy and disease-specific cohorts. Evenson et al. [9] published the most recent systematic review on the validity of consumer wearables to monitor PA, and reported at the time of the search in 2014 only one study [4] had an older adult sample. Therefore, this systematic review aims to provide an update on prior evidence, with a specific focus on studies reporting the validity and reliability of consumer-grade activity trackers in older, community-dwelling adults.

## 2. Methods

### 2.1. Search strategy

The review was guided by Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) [10], with inclusion criteria and methods of analyses decided in advance. We performed a systematic search of three electronic databases MEDLINE, CINAHL and COCHRANE Central Register of Controlled Clinical Trials, from November 2014 to January 2018. For the purpose of this review, the keywords searched included 'older'; 'physical activity'; 'exercise'; 'steps'; 'tracker'; 'wearable'; 'consumer-grade' and 'measure' amongst others. Additional manual searches of reference lists from eligible papers; related trial bibliographies; conference abstracts and Google Scholar (Fig. 1) were undertaken. The eligibility of articles was independently assessed by

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