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Review

The impact of wearable motion sensing technology on physical activity in older adults

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ABSTRACT

Background and purpose: Physical activity provides substantial health benefits. Older adults are less physically active than the rest of the population, and interventions that promote physical activity are needed. In this meta-analysis, we investigate how different wearable activity trackers (pedometers and accelerometers) may impact physical activity levels in older adults.
Methods: We searched MEDLINE, Embase and CINAHL for randomized controlled trials including participants that were ≥65 years, using wearable activity trackers with the intent of increasing physical activity. Studies whose comparator groups were engaged in active or inactive interventions, such as continued a physical therapy program or goal-setting counseling, were not excluded simply for implementing co-interventions. We used random-effects models to produce standardized mean differences (SMDs) for physical activity outcomes. Heterogeneity was measured using I^2.
Results: Nine studies met the eligibility criteria: Four using accelerometers, four using pedometers, and one comparing accelerometers and pedometers, for a total number of 939 participants. Using pooled data, we found a statistically significant effect of using accelerometers (SMD = 0.43 (95%CI 0.19–0.68), I^2 = 1.6%, p = 0.298), but not by using pedometers (SMD = 0.17 (95%CI −0.08–0.43), I^2 = 37.7%, p = 0.174) for increasing physical activity levels.
Discussion and conclusions: In this study, we found that accelerometers, alone or in combination with other co-interventions, increased physical activity in older adults however pedometers were not found to increase physical activity. The high risk of bias found in most studies limits these findings. High quality studies that isolate the effects of accelerometers on physical activity changes are needed.

1. Introduction

It has been demonstrated that regular physical activity in older adults plays an important role in maintaining mental and physical health (Centers for Disease Control and Prevention, 2015). For older adults, increasing daily physical activity may reduce the risk of certain conditions, help maintain weight, strengthen bones and muscles, improve mental health, decrease chance of falls, improve overall function, reduce healthcare expenditure and increase life expectancy (Centers for Disease Control and Prevention, 2015). Despite well-known evidence to support the benefits of physical activity, older adults are reported to be the most inactive population, with approximately 43.4% of adults aged 65–74 who report leisure-time activity meeting the federal physical activity guidelines for aerobic activity, 15.5% meeting the guidelines for aerobic and muscle strengthening, and approximately one in four adults aged ≥50 years reporting no physical activity outside of work (Centers for Disease Control and Prevention, 2013; Ward et al., 2016; Watson et al., 2016). Additionally, as of 2015, 21.7% of adults aged

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≥65 rate their health as poor and the prevalence of obesity in adults aged ≥60 is 30.1% in the United States (National Center for Health Statistics, 2016; Ward et al., 2016). Walking, a preferred form of exercise for older adults (Centers for Disease Control and Prevention, 2013), may be a relatively safe and efficient way to achieve daily recommended amounts of physical activity. Self-monitored walking may be done easily with small, unobtrusive wearable activity trackers.

Implementing self-monitoring and feedback in order to positively affect physical activity behavior, goal attainment, and adherence has shown success in previous systematic reviews, yet these reviews also suggest the need for further investigation (Burke et al., 2011; Stephens and Allen, 2013). Pedometers and accelerometers have been found feasible for self-monitoring movement in older adult populations (de Bruin et al., 2008), despite suggestions that older adults face challenges using this technology (Wandke et al., 2012). Pedometers track steps in one plane of motion based on trunk swing during gait. Accelerometers combine tri-planar motions to better detect steps. Both devices are relatively simple, valid, and reliable tools designed to objectively detect physical activity. Furthermore, pedometers are considered more affordable and easy to use with little training (Tudor-Locke and Lutes, 2009). Some limitations noted with pedometers are the inability to capture intensity as well as underestimating step-count in certain populations with slower ambulation speeds (Le Masurier and Tudor-Locke, 2003; Tudor-Locke et al., 2002). In comparison, more expensive accelerometers may overcome the previously mentioned limitations with the potential to detect multi-planar movement and intensity levels (Aparicio-Ugarriza et al., 2015). While both pedometers and accelerometers offer opportunities for objective self-monitoring, accelerometers provide data in real-time via computer programs that allows for in depth analysis and third party participation (Gonzalez et al., 2013; Lyons et al., 2014).

Current systematic reviews and meta-analyses that focus individually on accelerometers or pedometers have shown positive effects on increasing physical activity in the general adult population (Goode et al., 2016; Kang et al., 2009). To our knowledge, no previous systematic review has conducted a comparative analysis of the effects of wearable motion sensing technology (pedometers and accelerometers) in older adults, a population at high risk of adverse health sequelae as a result of sedentary behavior (Watson et al., 2016). Therefore, the purpose of this systematic review was to determine the effect of interventions that incorporate wearable motion sensing technology and compare efficacy of accelerometers and pedometers in increasing older adult physical activity levels. Information gained from this systematic review may help guide physical activity intervention plans for older adults or future research.

2. Methods

We followed a standard protocol for this review, conducting it in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement. Each step was pilot-tested to train and calibrate study investigators.

2.1. Data sources and search strategy

We searched MEDLINE (via PubMed), Embase, and CINAHL from each respective database inception date to May 2017. We used Medical Subject Heading (MeSH) terms and selected free-text terms for wearable activity monitors and for outcomes of interest (e.g., movement, exercise therapy, physical fitness) along with validated search terms for study designs of interest. Each bibliography of included trials and systematic reviews was reviewed for missed publications. A complete listing of the search strategy can be found in Appendix A.

2.2. Eligibility criteria

To be included, studies had to (1) include a sample of over 75% adults ≥65 years of age as determined by a mean age and standard deviation, (2) use wearable motion sensing technology (accelerometer or pedometer) within an intervention designed to increase physical activity or compare devices in increasing physical activity, (3) report changes in the outcomes of physical activity (i.e. daily steps, minutes walking, etc.) (4) be a randomized controlled trial (RCT) with a total sample size of > 20 participants and outcomes > 6 weeks, and (5) be published in an English-language peer-reviewed journal. Studies were excluded if they did not include a population of interest, did not include an outcome of interest or were a pilot or feasibility study due to the potential for low quality or high risk of bias. Studies whose comparator groups were engaged in co-interventions, whether active or inactive interventions, such as continued a physical therapy program or goal-setting counseling, were not excluded simply for implementing co-interventions. A detailed list of eligibility criteria can be found in Appendix A.

2.3. Screening and eligibility

Two trained investigators screened titles and abstracts (CC and ADG) against eligibility criteria. Full-text articles identified by either investigator as potentially relevant were retrieved for further review and examined by two investigators (CB and RP) against the eligibility criteria. Disagreements were resolved by discussion or by a third investigator (CC). In addition, trials with three or more arms were examined for appropriateness of all arms for inclusion.

2.4. Data abstraction

Data from included trials were abstracted into a customized database by a trained investigator and confirmed by a second investigator. Disagreements were resolved by consensus or by obtaining a third investigator's opinion when consensus could not be reached. We grouped the devices into two categories as to whether the manufacturer classified the device as a pedometer or accelerometer. Each device may have a different accuracy (sensitivity or specificity) for measuring physical activity, and these differences may influence the overall summary estimate for each wearable device category. However, we anticipate these influences to be small since most accelerometers have high accuracy values (de Bruin et al., 2008). Data elements included date of publication, sample size, population characteristics (e.g., chronic medical illness status, sex, age), and descriptors to assess applicability, quality elements, and outcomes. Key intervention characteristics abstracted were the type of activity monitor (e.g., brand, location worn on body), type of adjunctive intervention (e.g., counseling and goal setting education), and duration as well as frequency of intervention.

2.5. Risk of bias

We used key quality criteria described in the Cochrane Collaboration Risk of Bias Tool to assess risk of bias in each included study. The tool evaluates six different domains across seven questions: (1) selection bias (i.e., adequacy of random-sequence generation, allocation concealment), (2) performance bias for each outcome (i.e., knowledge of allocated intervention by participants and study personnel that could introduce bias), (3) detection bias for each outcome (i.e., knowledge of allocated intervention by outcome assessors), (4) attrition bias (i.e., amount, nature, or handling of incomplete outcome data), (5) reporting bias (i.e., selective outcome reporting), and (6) other bias (e.g., differences in relation to baseline measures, reliable primary outcomes, protection against contamination).

We evaluated each domain as low, unclear, or high risk of bias. An overall score of low risk of bias required selection bias related to