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Review article

Objective measurement of physical activity outcomes in lifestyle interventions among adults: A systematic review

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ABSTRACT

Valid, reliable, and direct measures of physical activity (PA) are critical to assessing the impact of lifestyle PA interventions. However, little is known about the extent to which objective measures have been used to assess the outcomes of lifestyle PA interventions. This systematic review had two aims: 1) evaluate the extent to which PA is measured objectively in lifestyle PA interventions targeting adults and 2) explore and summarize what objective measures have been used and what PA dimensions and metrics have been reported. Pubmed, Cochrane Central Register, and PsychInfo were searched for lifestyle PA interventions conducted between 2006 and 2016. Of the 342 articles that met the inclusion criteria, 239 studies measured PA via subjective measures and 103 studies measured PA via objective measures. The proportion of studies using objective measures increased from 4.4% to 70.6% from 2006 to 2016. All studies measuring PA objectively utilized wearable devices; half (50.5%) used pedometers only and 40.8% used accelerometers only. A majority of the 103 studies reported steps (73.8%) as their PA metric. Incorporating objective measures of PA should continue to be a priority in PA research. More work is needed to address the challenges of comprehensive and consistent collecting, reporting, and analyzing of PA metrics.

1. Introduction

Physical inactivity is responsible for 1 out of 10 premature deaths worldwide and is a risk factor for numerous chronic diseases including obesity, type 2 diabetes, cardiovascular disease, and some types of cancer (Lee et al., 2012). The World Health Organization recommends that adults engage in at least 150 min of moderate-intensity physical activity per week in order to receive the well-documented benefits of regular physical activity such as weight control, improved mental health and mood, and a reduced risk of chronic disease and all-cause mortality (Global recommendations on physical activity for health, 2016; Blair et al., 1996; Medicine ACoS, 2017). Unfortunately, about 1 in 4 adults worldwide are insufficiently active, and physical inactivity is more common in high-income countries compared to low-income ones (Hallal et al., 2012). As of 2012, the prevalence of inactivity was 43.3% in the Americas versus 27.5% and 17% in Africa and Southeast Asia, respectively (Hallal et al., 2012). Thus, development of strategies to increase the physical activity levels of adults is critical to reduce the global burden of chronic disease.

Given the high rates of physical inactivity, attention has focused on developing and testing lifestyle interventions that promote leisure-time physical activity and increase the number of adults meeting the public health recommendations for physical activity (Kahn et al., 2002; Dunn et al., 1998). These interventions often take into account individual, cultural and environmental factors influencing health behaviors and allow participants to individualize their physical activity programs to best fit their own life circumstances (Dunn et al., 1998). The ability to reliably measure the impact of these interventions on physical activity is critical for progress in this area of public health promotion (Welk, 2002). Thus, valid, reliable, and direct measures of physical activity are needed to understand the impact of lifestyle physical activity interventions (Welk, 2002; Kelly et al., 2016).

A review published in 2001 estimated there to be more than a dozen methods to measure physical activity, often categorized into subjective and objective measures (Tudor-Locke and Myers, 2001). Comprehensive summaries of these methods have been published elsewhere, (Welk, 2002; Strath et al., 2013) and are briefly outlined in a supplemental file (File S1). The most common measurement types are

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subjective (or self-report) measures, which include tools such as physical activity diaries and recall questionnaires, and are considered practical, versatile, low cost, and easy to use (Welk, 2002; Tudor-Locke and Myers, 2001; Ainsworth et al., 2015; Blair, 1984). However, subjective measures present limitations in capturing physical activity due to poor reliability and validity, participant recall bias and interpretation of questions, and floor effects created by instruments failing to capture the lower end of the physical activity spectrum such as spontaneous or light activities (e.g., household chores, family care) (Welk, 2002; Tudor-Locke and Myers, 2001; Prince et al., 2008). Objective methods include measures that directly assess one or more dimensions of physical activity (e.g., frequency, intensity, time, type), and have the ability to capture a variety of metrics such as number of steps, minutes of activity, intensity of activity, and bouts of activity (Strath et al., 2013). Although it has been argued that there is no "gold standard" for objective physical activity measurement, (Kelly et al., 2016; Ridgers and Fairclough, 2011; Aparicio-Ugarriza et al., 2015) commonly used tools include: wearable monitors (e.g. accelerometers, pedometers, and heart rate monitors) as well as indirect calorimetry and direct observation. Physical activity is a multifaceted and complex behavior, and research has shown that these objective measures are more precise compared to subjective measures, (Welk, 2002; Freedson and Miller, 2000) better capture the intricacies of physical activity dimensions, (Kelly et al., 2016; Prince et al., 2008) and provide a more continuous evaluation of free-living activity (Yang and Hsu, 2010).

Given these advantages, epidemiological and observational studies have begun to utilize objective measures (e.g. accelerometers) of physical activity to describe physical activity patterns across diverse population subgroups (e.g., healthy adults and children, and adults with diabetes, chronic obstructive pulmonary disease [COPD], and arthritis) (Troiano et al., 2014; Troiano, 2005; Loprinzi et al., 2014; Lee et al., 2013; Colley et al., 2011). However, while guidelines have been outlined for selecting physical activity measurement tools for use in lifestyle physical activity interventions, (Strath et al., 2013; Freedson et al., 2012; Bowles, 2012) little is known about the extent to which objective compared to subjective measures have been actually incorporated into these interventions. To advance the field of physical activity measurement in the context of lifestyle physical activity interventions, a summary of the use of recent methods is needed. Therefore, the purpose of this systematic review was to 1) evaluate the extent to which physical activity is measured objectively in lifestyle interventions targeting physical activity in adults and 2) explore and summarize what objective measures techniques have been used as well as physical activity dimensions and metrics that were reported.

2. Methods

2.1. Search procedure

The search strategy for this review was developed by a trained research librarian with experience in conducting systematic reviews. A computerized search was conducted in March 2016 for peer-reviewed original research published in English after January 1, 2006. The following databases were searched: Pubmed, Cochrane Central Register, and PsychInfo. The keywords in the search included ("physical activity" OR "physical activities" OR "exercise" OR "leisure time physical activity" OR "leisure time physical activities") AND ("intervention" OR "interventions" OR "randomized controlled trial" OR "comparative study" OR "clinical trial").

2.2. Selection criteria

Studies were included if they were randomized controlled trials or quasi-experimental interventions focused on increasing lifestyle physical activity among adults (≥18 years of age). Articles also needed to be published in English, peer-reviewed, and published between January 1, 2006 and March 30, 2016.

The focus of this paper was to examine lifestyle interventions centered on increasing physical activity among free-living adults. Thus, studies were excluded if they targeted inpatient populations, were not interventions containing at least two groups (i.e., observational, cross-sectional, secondary analyses), or if they were structured, supervised exercise interventions conducted in lab-based settings. Studies were also excluded if weight, diet, fitness, or other metabolic outcomes (e.g. glucose, cholesterol) were considered the primary focus and/or outcome of the intervention. Finally, studies were excluded if the intervention addressed multiple lifestyle behavior changes or general health behavior change. An example of this would be a study that was framed around diabetes self-management versus focused specifically on increasing physical activity.

2.3. Data extraction and synthesis

Five reviewers (VS, CH, ALC, CM, MS) screened titles and abstracts of the studies to identify potentially relevant articles. Reviewers were paired together so that each title and abstract was screened independently by two reviewers, and discussed discrepancies in eligibility until a consensus of inclusion or exclusion was determined. Interrater agreement (IRA) for titles and abstracts was 99.6% and 89.7% agreement, respectively. After this screening process, remaining eligible articles were selected for full text reviews.

A standardized data abstraction form was utilized for full text review. The data abstraction form was drafted by one author (VS) with input from the research team and was then piloted by reviewers with a set of five randomly selected articles prior to beginning full text data extraction. All the reviewers met to discuss discrepancies with the form which was edited and finalized prior to the full text review. A finalized document with the agreed upon coding procedures was created in the data management tool REDcap and used by a total of six authors (VS, CH, ALC, DJS, CM, MS) during the full text review process. During the data abstraction phase, each article was reviewed separately by two reviewers. Disagreements in abstracted data and article eligibility were discussed by the authors until consensus was reached. IRA between the reviewers was calculated for each abstracted variable and values are reported below.

2.3.1. Aim 1

The first step in data synthesis was to determine the proportion of lifestyle physical activity interventions that utilized objective measures of physical activity (e.g., pedometer, accelerometer) versus subjective, self-report measures only (IRA = 75.7%). For articles that only measured physical activity outcomes via subjective measures, full text reviews ceased after the citation information and the name of the self-report measure(s) were extracted. The percentage of lifestyle interventions that utilized objective measures was calculated by taking the proportion of studies using objective measures out of all included articles. The proportion of all included articles that utilized objective measures per year of publication from 2006 to 2016 was also calculated.

2.3.2. Aim 2

Articles included in Aim 2 were reviewed for the components of the objective physical activity measures that were utilized in the study. *Type of Measure.* Reviewers selected from a list of all measurement types including both subjective and objective measures: self-report, direct observation, pedometers, heart rate monitors, accelerometers, multi-sensor devices, indirect calorimetry, and double-labeled water (IRA = 92.2%). Reviewers could select more than one measurement type, where applicable. *Name of Measure.* For included articles, reviewers recorded the name, make, and model of the measurement type in a textbox (IRA = 90.3%). *Physical Activity Metrics.* Reviewers selected the physical activity metrics that were collected and reported by