Contemporary Clinical Trials 64 (2018) 13–21

Contents lists available at ScienceDirect

Contemporary Clinical Trials

journal homepage: www.elsevier.com/locate/conclintrial

Review

Wearable activity monitors in oncology trials: Current use of an emerging technology

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ARTICLE INFO

Keywords:
Cancer
Oncology trials
Physical activity
Wearable activity monitors
Wearable technology
Outcome assessment
Cancer survivorship

ABSTRACT

Background: Physical activity is an important outcome in oncology trials. Physical activity is commonly assessed using self-reported questionnaires, which are limited by recall and response biases. Recent advancements in wearable technology have provided oncologists with new opportunities to obtain real-time, objective physical activity data. The purpose of this review was to describe current uses of wearable activity monitors in oncology trials.

Methods: We searched Pubmed, Embase, and the Cochrane Central Register of Controlled Trials for oncology trials involving wearable activity monitors published between 2005 and 2016. We extracted details on study design, types of activity monitors used, and purpose for their use. We summarized activity monitor metrics including step counts, sleep and sedentary time, and time spent in moderate-to-vigorous activity.

Results: We identified 41 trials of which 26 (63%) involved cancer survivors (post-treatment) and 15 trials (37%) involved patients with active cancer. Most trials (65%) involved breast cancer patients. Wearable activity monitors were commonly used in exercise (54%) or behavioral (29%) trials. Cancer survivors take between 4660 and 11,000 steps/day and those undergoing treatment take 2885 to 8300 steps/day.

Conclusion: Wearable activity monitors are increasingly being used to obtain objective measures of physical activity in oncology trials. There is potential for their use to expand to evaluate and predict clinical outcomes such as survival, quality of life, and treatment tolerance in future studies. Currently, there remains a lack of standardization in the types of monitors being used and how their data are being collected, analyzed, and interpreted.

Precis: Recent advancements in wearable activity monitor technology have provided oncologists with new opportunities to monitor their patients' daily activity in real-world settings. The integration of wearable activity monitors into cancer care will help increase our understanding of the associations between physical activity and the prevention and management of the disease, in addition to other important cancer outcomes.

1. Introduction

Physical activity is associated with improved outcomes and quality of life in cancer survivors [1,2]. Given the importance of physical activity to health and recovery, the majority of oncology trials involve tools to capture activity-related measures including exercise, sleep, energy expenditure, and functional performance. While a number of validated questionnaires have been used extensively to estimate physical activity and sleep, they are based on self-report and limited by recall and response biases [2,3]. Thus, physical activity tends to be overestimated with regards to activity frequency, duration, and intensity [4].

Recent technological advances in wearable activity monitors, have created new opportunities to collect continuous, objective patient data in a non-obtrusive manner. Wearable activity monitors measure movement to estimate the number of steps taken each day, distance travelled, energy expenditure, sleep parameters, and heart rate, among other activity metrics. There are different types of wearable devices that

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https://doi.org/10.1016/j.cct.2017.11.002
Received 5 August 2017; Received in revised form 16 October 2017; Accepted 1 November 2017
Available online 09 November 2017

can be used to monitor components of daily activity. This review focuses on wearable activity monitors used for monitoring and tracking fitness-related metrics. Devices commonly used are: (1) Pedometers: "estimate the number of steps taken through mechanical or digital measurements in only the vertical plane"; (2) Accelerometers: "Detect acceleration in one, two or three directions to determine the frequency, quantity and intensity of movements"; (3) Integrated multisensor systems: "Combine accelerometry with other sensors that capture body responses to exercise (e.g. heart rate) in an attempt to optimize physical activity assessments." [5–7].

Although pedometers have been used to record step counts for decades, the emergence of contemporary activity monitors into oncology trials is relatively new. With the rapid technological advancements of wearable activity monitors and complex systems in place to measure different components of activity, the use and applications of activity monitors in healthcare has broadened. Currently, there is a lack of knowledge on how wearable activity monitors are being integrated into the design and conduct of clinical trials. Furthermore, there is a need to better understand physical activity levels as measured using wearable activity monitors in cancer survivors or patients undergoing cancer treatment, as most studies have focused on summarizing physical activity levels in healthier populations. Thus, we conducted a review of the literature: (1) Describe current uses of wearable activity monitors in oncology trials; (2) Summarize physical activity patterns in cancer patients; (3) Identify opportunities for future applications. Findings from this review will provide information on the use of this emerging technology and on current physical activity levels of cancer survivors.

2. Methods

2.1. Eligibility criteria

Eligible studies were limited to randomized controlled cancer trials that used activity monitors to gain understanding of their specific use in controlled settings. Study participants could be either newly diagnosed, undergoing active treatment, or survivors of any cancer type. All activity monitors were considered eligible if they could be worn (e.g., on the wrist, arm, waist, hip, or ankle) and were used to track any form of physical activity. Activity metrics of interest included step count, activity count, energy expenditure, sleep, heart rate, duration of activity or any other form of physical activity that can be tracked and monitored by a wearable device. Published clinical trial protocols were reviewed and summarized for trials that are ongoing or not yet complete. Validation studies and other non-randomized or quasi-randomized studies were not included in the review. The search was limited to RCTs published between 2005 and 2016, to capture the more contemporary applications of devices. No language restrictions were applied.

2.2. Search strategy

While this was not intended to be a formal systematic review of the literature, we followed similar methods when screening and reviewing articles. Search terms for the population and devices were combined to identify studies for inclusion in Medline, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), and conference abstracts. Study screening, selection and data extraction were completed in Covidence- a Cochrane tool specifically used for systematic reviews. Two independent reviewers (GG & LG) screened titles and abstracts. Discrepancies were discussed and a third reviewer (AS) was consulted if needed. Full-text review was conducted in a similar manner.

2.3. Data extraction

Details on study design, interventions and outcomes of interest were extracted. Study details including study title, authors, year, country and registration number; study design (e.g., parallel, crossover, adaptive…); number of arms; number of participants; study duration and follow-up time were recorded. Primary and secondary outcomes were recorded and further categorized as "Physical activity"; "Behavioral/Cognitive"; "Quality of Life/Functional status"; and "Treatment/Survival" outcomes. Information on the study population including the cancer type (s), age groups, gender, and other baseline characteristics were extracted. Details of the devices used were recorded including the name and manufacturer of device, type of device (pedometer/accelerometer/multi-sensor system), placement, total wear-time, definition of valid wear-time and device output were recorded. If available, adherence rates and information on valid wear-days were extracted. Study results were extracted if they provided a step count or total time spent active and sedentary/asleep. Data from the baseline visit of the study population or control group (if overall data not reported) were used for the quantitative analysis.

2.4. Statistical analysis

Summary statistics were generated for trial characteristics. Where applicable, the average daily step count, sleep duration, sedentary time, and active minutes were summarized and plotted. Studies that did not report these activity data were excluded from the quantitative analysis. STATA version 13.0 was used for all analyses.

3. Results

The initial search identified 508 individual studies. Further screening of titles and abstracts yielded 71 trials to be included for full-text review. Excluded were multiple reports of the same trial, non-cancer trials, and trials that were not fully randomized. After full-text review, a total of 41 randomized clinical trials involving wearable activity monitors in cancer populations were included (Fig. 1). Trials were published between January 1st, 2005 and December 31st, 2016. Most trials were conducted in North America (USA/Canada) (68%). Additional study locations included Europe (15%), Asia (7%) and other countries (10%). Characteristics of the included trials are displayed in Supplementary Table 1.

3.1. Population

Over half of the trials were done in individuals who had completed treatment or were considered by their oncologist to have no evidence of disease (survivors) (n = 26, 63%). The majority of these were breast cancer patients (n = 17, 65%), followed by multiple cancer types

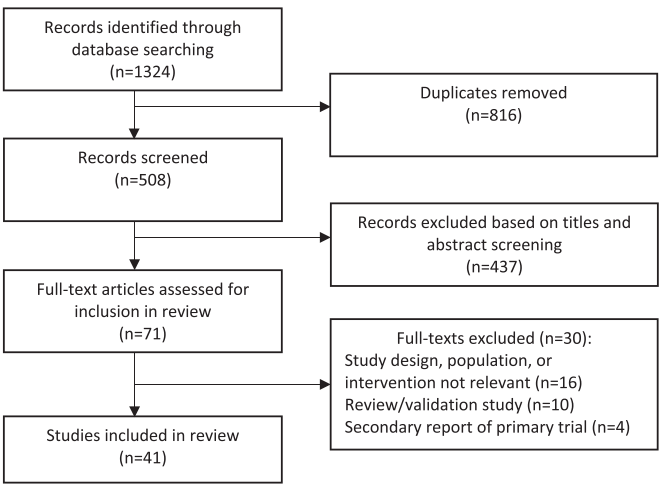

Fig. 1. Study selection flowchart.