Advantages and Limitations of Wearable Activity Trackers: Considerations for Patients and Clinicians

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Background: Exercise, light physical activity, and decreased sedentary time all have been associated with health benefits following cancer diagnoses. Commercially available wearable activity trackers may help patients monitor and self-manage their behaviors to achieve these benefits.

Objectives: This article highlights some advantages and limitations clinicians should be aware of when discussing the use of activity trackers with cancer survivors.

Methods: Limited research has assessed the accuracy of commercially available activity trackers compared to research-grade devices. Because most devices use confidential, proprietary algorithms to convert accelerometry data to meaningful output like total steps, assessing whether these algorithms account for differences in gait abnormalities, functional limitations, and different body morphologies can be difficult. Quantification of sedentary behaviors and light physical activities present additional challenges.

Findings: The global market for activity trackers is growing, which presents clinicians with a tremendous opportunity to incorporate these devices into clinical practice as tools to promote activity. This article highlights important considerations about tracker accuracy and usage by cancer survivors.

The benefits of physical activity both prior to and following a cancer diagnosis have been well-documented and include improvements in both overall and disease-free survival (Lynch, Dunstan, Vallance, & Owen, 2013). Exercise and light physical activity have been shown to improve management of symptoms such as pain, fatigue, anxiety, depression, and sleep-wake disturbances (Pinto & de Azambuja, 2011; Vallance, Boyle, Courneya, & Lynch, 2015; Weis, 2011). Physical activity also reduces bone loss and deconditioning, and decreases the risks of metabolic syndromes and other noncancer chronic conditions post-treatment (Lynch, 2010; Wiseman, Lynch, Cameron, & Dunstan, 2014). A growing body of research suggests that reducing and breaking up sedentary time decreases the risk of an initial cancer diagnosis, comorbidities associated with cancer, and cancer recurrence (Friedenreich & Lynch, 2012; Lynch, 2010; Wiseman et al., 2014). Large epidemiological studies indicate that cancer survivors often engage in less overall physical activity and lighter intensity activity than those without a cancer diagnosis (Phillips, Petroski, & Markis, 2015). Although some cancer survivors may engage in greater amounts of moderate-to-vigorous physical activity (MVPA) than others, most still do not achieve the recommended levels of exercise (Kim et al., 2013). Cancer survivors also tend to be more sedentary (Kim et al., 2013; Phillips et al., 2015). These trends may be related to multiple factors, including ongoing symptoms of fatigue and other late effects of cancer therapies (Berger, Gerber, & Mayer, 2012; Fodeh et al., 2013; Gaskin et al., 2016; Wood, Nail, & Winters, 2009).

These findings have led to widespread practice initiatives, such as the Oncology Nursing Society’s Get Up, Get Moving campaign, which encourages people with cancer diagnoses to be more active both during and following cancer treatment (Cannon, 2014). Activity trackers may be useful tools in
assisting patients in the self-management of activity and sedentary behavior habits, providing motivation to increase physical activity.

The purpose of this article is to highlight some of the advantages and potential limitations of commercially available activity trackers—specifically, their accuracy—to inform clinicians’ discussions of these devices with cancer survivors. Particularly, this article will focus on the accuracy of these monitors when used by cancer survivors.

Activity Tracker Use

Increasingly, cancer survivors are using wearable monitoring devices like the FitBit®, UP® by JawBone, Garmin Vivofit®, and Misfit Shine® to analyze their daily activity patterns and track their progress toward reaching activity goals (Kuipers, Groen, Aaronson, & van Harten, 2013; Rogers, 2010). Most of these devices rely on triaxial accelerometer sensors to detect motion and quantify activity. These data are linked to activity tracker websites or phone-based apps that allow cancer survivors to monitor and store information on their daily total activity (e.g., step counts, numbers of stairs climbed, minutes spent exercising), estimated total energy expenditures (e.g., calories burned), and patterns of physical activity during the course of a day. Many of the most recent models track sleep patterns and activity intensity by heart rate. Numerous pilot studies and a few larger-scale intervention trials have tested the use of such devices to increase physical activity and energy expenditure among patients with cancer and patients with chronic illnesses (Bourke et al., 2013; Friedenreich et al., 2014; Hawkes, Gollschewski, Lynch, & Chambers, 2009; Kuipers et al., 2013; Lynch, Courneya, Sethi, Patrao, & Hawkes, 2014). The market for these devices continues to expand as mobile health and personal health technologies gain popularity among consumers and clinicians. Activity tracker sales are projected to surpass $5 billion by 2019 (Park Associates, 2015). As commercial devices are integrated into patient plans of care, clinicians should be aware of their potential advantages and limitations.

Accuracy of Energy Expenditure Estimates

Commercially available activity trackers use algorithms to convert accelerometer data to measures of physical activity, such as total steps, time spent moving, and estimated energy expenditure. These algorithms are often proprietary and confidential, and may or may not account for differences in performance measurements across certain populations, such as people with gait abnormalities, functional limitations, or different body morphologies, or those who use assistive devices.

The limited research comparing the performance of commercially available activity trackers and research-grade activity trackers in clinical populations and older adults shows that commercially available devices significantly overestimate or underestimate total activity (e.g., steps) and energy expenditure in nonsystematic ways (Sasaki et al., 2015). In one study evaluating the performance of the FitBit and the Actigraph GT1M, both devices were found to underestimate true steps in a sample of 50 older adults aged 69–100 years. The FitBit also failed to detect steps in 25% of the older adults who used assistive devices, suggesting that the FitBit might not be appropriate for tracking activity in adults with lower gait speeds (less than 0.56 m/s) and in those who use assistive devices (Phillips et al., 2015).

A major limitation of the research to date is that most studies examining the accuracy of these devices have been conducted in laboratory settings as opposed to free-living conditions where the devices are primarily used. However, Ferguson, Rowlands, Olds, and Maher (2015) evaluated seven commercially available activity tracking devices in healthy adults in free-living conditions and found that most devices accurately recorded steps, but measures of total daily energy expenditure and MVPA were less accurate. Much variability was reported among the measurement accuracies across the devices (Ferguson et al., 2015).

These limitations have important implications for consumers and clinicians. If survivors use devices that dramatically underestimate activity and energy expenditure, they may overcompensate by overexercising and risk exhaustion or injury. Overestimation of total energy expenditure could also lead survivors to reduce activity levels and adherence to activity prescriptions.

In early 2016, a class action lawsuit was filed against one of the leading activity tracker manufacturers, alleging that their devices repeatedly demonstrated significant inaccuracies (less than 24 beats per minute, on average) in continuous heart-rate monitoring during exercise (Austin, 2016). Although continuous heart-rate monitoring is usually advertised by companies as an additional tool for assessing and adjusting exercise intensity, some consumers may rely on their estimates for medical indications. Until the accuracy and reliability of activity trackers’ continuous heart-rate monitoring technology are better established through nonindustry-funded research studies, cancer survivors should be cautioned against overreliance on their estimates.

This may be particularly important for survivors taking cardiac medications like beta blockers, or who have cardiomyopathy as a result of cancer therapies, or other comorbidities.

Detection of Sedentary Behaviors and Low-Intensity Physical Activity

Increasing evidence points to the potential health benefits of interrupting and reducing sedentary behavior patterns, and the value of light physical activity (Lynch et al., 2009, 2011, 2013; Owen, Healy, Matthews, & Dunstan, 2010). Sedentary behavior has been defined as activity that does not substantially increase energy expenditure above resting level, such as lying down and sitting (Pate, O’Neill, & Lobelo, 2008). Physiologically, this has been operationalized as activities with an energy expenditure of up to 1.5 METs (1.5 times baseline or resting metabolic rate) (Owen et al., 2010). Light physical activities include washing dishes, cooking food, and walking slowly, in which energy expenditure ranges from 1.6–2.9 METs (Pate et al., 2008).

Most activity-based interventions focus on increasing levels of MVPA (less than 3 METs), but an independent association

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exists between increased light-intensity physical activity, decreased sedentary time, and clinically significant metabolic outcomes, such as changes in two-hour plasma glucose levels (Healy et al., 2007). Pate et al. (2008) have also demonstrated how, during the course of a typical day, even light physical activity contributes significantly to total daily energy expenditure. Given the challenges of cancer survivors in achieving nationally recommended levels of MVPA, researchers have suggested that increasing light physical activity and disrupting sedentary behavior may be more realistic targets for behavior change in this population (Bourke et al., 2013).

However, evaluations of activity tracking monitors in free-living conditions indicate that devices such as the FitBit may not accurately detect light physical activities and sedentary time (Boyle, Lynch, Courneya, & Vallance, 2014; Sasaki et al., 2015, 2016). In addition, most consumer devices do not incorporate tilt sensors or inclinometers and, therefore, are not designed to accurately detect changes in posture, such as sitting down, standing up, or lying down.

**Monitor Placement and Ease of Use**

Commercially available activity monitors appear to be highly acceptable and increasingly used in large and diverse groups of people, including those with low baseline levels of activity. Unlike earlier models of activity trackers, which required syncing to a computer using a USB cable, Bluetooth-equipped and WiFi-compatible devices can now transmit data to handheld mobile devices, eliminating the burden of hardwire connections between monitors and computers or smartphones. Cadmus-Bertram, Marcus, Patterson, Parker, and Morey (2015) studied the use of activity trackers among 51 inactive, postmenopausal women with a body mass index greater than 25 in a 16-week physical activity intervention. Intervention group participants received a FitBit and were asked to perform 150 minutes of MVPA per week. Intervention group participants increased MVPA by 62 minutes per week and wore the tracker 95% of the time. All the participants reported liking the tracker, and 96% of the participants reported liking the website associated with the tracker (Cadmus-Bertram et al., 2015). However, even when consumer devices are easy to use and acceptable to cancer survivors, monitor accuracy still varies depending on the activity and the placement of the monitor. Some monitors (e.g., FitBit, Apple Watch™, Garmin VivoFit) should be worn on the dominant wrist, yet some cancer survivors have physical impairments as a result of the cancer illness, therapies, or surgeries that restrict movement in particular limbs. For example, breast cancer survivors who have undergone surgery sometimes experience a limited range of motion in the limb on the affected side. Other monitors, such as the Misfit Shine, can be worn on the hip, wrist, foot, or around the neck, although the accuracy of activity measurements when worn at each of these locations remains unknown. An evaluation of the research-grade device Actigraph GT3X found that wrist and hip placement contributed to less accurate total steps than when the monitor was worn around the ankle (Phillips et al., 2015). Consumer model algorithms for data calculation are proprietary; therefore, determining the optimal placement of these monitors is difficult without more research. In addition, research should examine how range of motion, gait abnormalities, and other movement disorders affect the performance of commercially available activity trackers.

**Role in Sustained Behavioral Change**

For a device to accurately report on changes in survivors’ daily activity patterns and progress toward goals, it must be worn consistently. A review of activity tracking devices and their associated apps found that, although most claimed to be designed according to theories of behavior change, very few used what research has established as the most effective interventions to promote conversion of intent to action (action planning). Lyons, Lewis, Mayrsohn, and Rowland (2014) evaluated 13 devices and found that six behavior change techniques were used in 76% of the activity tracking apps; goal setting, review of behavioral goals, identifying discrepancies between current behaviors and goals, feedback, self-monitoring, and adding objects to the environment. Behavior change techniques that were not typically incorporated into these devices included problem-solving, behavioral instruction, and commitment strategies (Lyons et al., 2014). Consumer-grade activity tracking devices align well with the behavioral change technique of self-monitoring, but without an action planning and commitment step, they may have less of an impact on actual behavioral change. In addition, most consumers stopped using these devices after six months or less (Ledger, 2014). Research evaluating the most effective types of data displays for the purposes of behavioral activation is still lacking. However, clinicians may be able to assist patients in reviewing their activity data and making decisions about their activity goals and action steps to meet those goals.

**Conclusion**

The science of activity monitoring for consumer use and research purposes is rapidly evolving. Many potential benefits exist for using commercially available activity tracking devices and associated apps, especially as the technology improves and as researchers increasingly incorporate these devices into rigorous clinical trials of behavioral interventions to promote health in the wake of cancer diagnoses. However, clinicians

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**Implications for Practice**

- Suggest that cancer survivors use personal health monitoring devices to self-manage their health and to motivate them to reach physical activity goals.
- Inform survivors that wearable activity trackers have some accuracy limitations and that activity counts may be affected by individual gait characteristics and body morphology, the degree of activity, and where and how a device is worn on the body.
- Warn patients that built-in continuous heart-rate monitors may yield gross estimates of exercise intensity and that they should not rely on them for medical applications.
and consumers should adopt these devices cautiously. Based on their advertising and highly quantitative displays of consumer data, some tracker monitors may promise benefits they cannot deliver in terms of data capture and accuracy. These devices' numerical outputs (total steps, kilocalories burned, heart rate, hours slept) may lead some consumers to place greater faith in their accuracy than is warranted. In addition to monitor accuracy, clinicians should also be aware of wider privacy issues associated with the generation and capture of potentially sensitive patient data on behavior patterns by commercial entities and, increasingly, social media users.

Oncology nurses should be aware of the inaccuracies of wearable activity trackers and discuss their limitations with cancer survivors. Their feedback may effectively promote self-management and sustain positive changes in physical activity, sedentarism, sleep, and other associated symptoms. In addition, nurses have access to many tools for incorporating activity assessment into their discussions on the importance of regular physical activity, such as Oncology Nursing Society's Get Up, Get Moving campaign, as well as multiple educational resources and exercise guidelines.

References


