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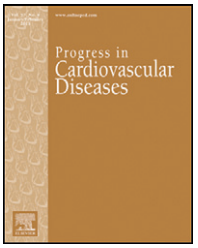

Utility of Consumer Physical Activity Trackers as an Intervention Tool in Cardiovascular Disease Prevention and Treatment

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ABSTRACT

Consumer activity trackers have grown in popularity over the last few years. These devices are typically worn on the hip or wrist and provide the user with information about physical activity measures such as steps taken, energy expenditure, and time spent in moderate to vigorous physical activity. The consumer may also use the computer interface (e.g. device websites, smartphone applications) to monitor and track achievement of PA goals and compete with other users. This review will describe some of the most popular consumer devices and discuss the user feedback tools. We will also present the limited evidence available about the accuracy of these devices and highlight how they have been used in cardiovascular disease management. We conclude with some recommendations for future research, focusing on how consumer devices might be used to assess effectiveness of various cardiovascular treatments.

Cardiovascular disease and physical activity

Cardiovascular disease (CVD) includes a cluster of diseases that affect the heart and blood vessels. It has major morbidity consequences and is the leading cause of death worldwide.[1,2] Annually, approximately $320 billion dollars in direct and indirect costs are spent in the treatment and management of CVD.[2] Therefore, considering how modifiable risk factors such as physical inactivity impact CVD morbidity and mortality is prudent. Numerous studies have shown that regular participation in physical activity (PA) has beneficial effects on CVD development, progression, and management. The body of knowledge about the positive effects of PA on CVD led to PA dose recommendations required for cardiovascular health benefits.[3] For example, the 2008 PA Guidelines for Americans recommend at least 150 minutes of moderate intensity or 75 minutes of vigorous intensity aerobic PA per week to reduce the risk of CVD.[4] A systematic review of research on CVD and PA that accompanied the 2008 Guidelines reported a 30–35% reduction in risk for developing CVD among the most active men and women compared to their least active counterparts.[5] The American Heart Association and American College of Sports Medicine PA recommendations also align with the 2008 Guidelines.[6] In addition, it has been shown that if individuals increase PA levels to meet guidelines, there may be reductions in health care expenditures in the United States.[7]

Despite evidence supporting the health benefits of PA, a large proportion of the adult population remains inactive.[8] Data from NHANES 2005 to 2006 indicated that fewer than

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Abbreviations and acronyms
AARP = American Association of Retired Persons
CVD = Cardiovascular disease
PA = Physical activity

10% of US adults met the 2008 Guidelines when PA was measured with an accelerometer. However, when PA was measured via self-report, 62% satisfied the established guidelines.[9] Potential explanations for these discrepancies in the prevalence of meeting PA guidelines are reporting bias and differential errors where individuals incorrectly report their PA or sedentary behavior. Although self-report measures are useful for certain activity measurement applications, wearable sensors measuring actual motion of the body rather than participant perceptions of PA provide a more accurate measure of these behaviors.

Recently, consumer-grade PA trackers have become popular devices for objectively assessing activity. These devices typically use accelerometer sensors and provide feedback to the user through a monitor display, smartphone applications (apps), or websites associated with the device. In addition to tracking PA for individual users, these feedback features motivate consumers to increase PA. This review focuses on the potential utility of these devices as behavior change drivers in individuals with CVD. We first describe the growth of the consumer wearable device market. Secondly, the accuracy of the consumer PA trackers and their effectiveness in changing PA behavior is discussed. Finally, we highlight current studies that have used these devices in populations at risk or currently suffering from CVD.

Consumer wearable device market

The American College of Sports Medicine survey of fitness trends reported that wearable technology was the top-rated trend for 2016.[10] It is projected that approximately 32 million wearable PA trackers will be sold by the end of 2016, and forecasts indicate that sales of these devices will exceed 82 million by 2019.[11] The smartwatch, which includes PA monitoring capabilities, also provides the consumer with PA tracking features. Although the cost of a smartwatch is two to three times the cost of PA trackers, sales of these devices are expected to increase dramatically over the next decade.[12] The availability of relatively low cost PA trackers ($30-$200) and positive marketing trends for such devices provide an exceptional opportunity for use in health care systems. These devices can be used in self-care management and for PA tracking by health care providers for individuals being treated for CVD and related risk factors where PA is known to have a positive impact.

Popular consumer wearable devices: accuracy and effectiveness to change physical activity behavior

Recent advances in technology and reduced costs of wearable devices have led to development of a plethora of these devices targeted for the consumer. Consumer technology reports cite Jawbone and Fitbit as dominant devices in this market.[13] Other popular devices are marketed by Apple, Garmin, Microsoft, Misfit, Polar, Samsung, and Withings. Consumer wearable devices utilize proprietary algorithms to estimate various metrics of PA such as steps taken, stairs climbed, calories expended, and distance traveled. Some of these devices also estimate different aspects of sleep (e.g. total hours of sleep, light sleep, deep sleep, awake time). Table 1 summarizes ten of the most popular consumer devices ranging in cost from $30 to $200. All of the devices described track calories, steps, distance, and PA minutes, but few provide more specific information about PA (e.g. stairs climbed, heart rate). All but one device (Fitbit Zip) track some aspect of sleep. Most of the devices are chargeable, and battery life lasts between two and 10 days. However, the Misfit monitor battery life lasts up to 6 months without requiring charging. Each device uses Bluetooth for data transmission, eliminating the need for a USB cable to upload data. The devices all provide some immediate feedback to the user; however, this feedback differs by device. For example, some provide actual data (e.g. calories burned) while others display red, yellow, and green lights on the face of the device to indicate progress towards some preset goal.

While this technology has the ability to help individuals track and modify their PA and sleep behaviors, there is a paucity of data regarding the accuracy and precision of wearable devices in the free-living environment. Most of the work examining the accuracy of these devices has been conducted in the laboratory. A recent lab study evaluated the accuracy of seven consumer devices (BodyMedia Fit, DirectLife, Fitbit One, Fitbit Zip, Jawbone UP Band, NikeFuel Band, and the Basis B1 Band) and one research-grade device (ActiGraph GT3X+) during 13 activities classified into sedentary, walking, running, and moderate-to-vigorous PA categories.[14] The mean absolute percent errors (MAPE) for energy expenditure ranged from 9.3–23.5%. The BodyMedia Fit, which is a consumer version of the SenseWear Armband and the Fitbit Zip, showed promising results in terms of MAPE and equivalence testing compared to indirect calorimetry.

In another recent lab investigation, the Fitbit classic was evaluated during a treadmill and a simulated free-living PA routine of nine activities.[15] It was reported that the device significantly underestimated energy expenditure for most PA, with the exception of laundry activity where energy expenditure was overestimated. This is not surprising, given that many of the tested devices are worn on the wrist and movements during laundry activity are mostly upper body movements involving the arms. A similar underestimation was observed for steps from the Fitbit in another sample of 50 older adults who completed two walking trials.[16]

Ferguson et al compared the performance of seven consumer-grade devices with that of two research-grade devices during 24 hours of free-living wear.[17] They reported that most consumer-grade devices accurately captured steps and sleep duration. The consumer device estimates of total daily energy and expenditure and time spent in moderate-to-vigorous PA had moderate to strong correlations with those of the research-grade devices, but across devices