Can We Use Consumer-Wearable Activity Tracker Fitbit in Parkinson Disease?

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Abstract

Consumer-wearable activity trackers have been used for monitoring health-related metrics to estimate steps, distance, physical activity, energy expenditure, and sleep. The purpose of this mini review was to summarize the evidence for validity of the most popular wrist-worn activity tracker (Fitbit) to estimate those health-related metrics in Parkinson disease. We researched full-length English studies in PubMed, Science Direct, Google Scholar, and Scopus, through September, 2021. In total, 27 studies and a textbook description were included in the review. To adapt consumer-wearable activity trackers for evaluating health-related metrics in Parkinson's disease (PD) patients, there may be some points to be elucidated and conquered. First, measurement accuracy and precision are required. Second, inter-device reliability for measuring steps, distance, and energy expenditure must be considered. Third, wearability: there are some types of device such as wrist-worn, ankle-worn, belt-fixed, and so on. Overall, Fitbit has advantage for these points. This mini review indicates that Fitbit has enough measurement accuracy and precision to estimate health-related metrics of PD patients including amount of step, physical activity energy expenditure, and quality of sleep.

Keywords

Parkinson Disease, Consumer-Wearable Activity Trackers, Fitbit, Physical Activity, Sleep

1. Introduction

There is consensus that physical activity has important for human brain health at any age [1] [2]. Sustainably and regularly conducting physical activity is recommended as a non-pharmacologic therapy for maintaining general health sta-

tus. For example, habitual exercise improves cardiorespiratory fitness and cardiovascular health, helps reducing body mass index, and can be effective for cardiovascular disease, for high blood pressure, and for brain dysfunctions [3] [4] [5] [6]. In addition, there is growing evidence for the beneficial effects of physical activity on several diseases, including neurodegenerative diseases [4] [6] [7]. To promote or maintain physical activity, self-monitoring usingpedometers and accelerometers have been considered effective [8]. However, the validity of estimating the amount of physical activity or physical activity energy expenditure detected using consumer-wearable activity trackers has not been sufficiently established [9]. In addition, advent of mobile health technologies makes it possible to wear or to carry devices during daily activities. Among those devices, some can detect sleep pattern that also disturbed among neurodegenerative diseases [10] [11]. Thus, consumer-wearable activity trackers for assessment of neurodegenerative diseases are required at least to evaluate physical activity, energy consumption, and quality of sleep.

Among neurodegenerative diseases, Parkinson's disease is the most popular disease that is characterized by resting tremor, bradykinesia, rigidity, and a series of non-motor symptoms, including sleep disorders, depression, pain, constipation, and genitourinary problems [12] [13]. To assess, motor signs and non-motor signs, only some questionnaires, such as Unified Parkinson's Disease Rating Scale (UPDRS) [13] have been used for evaluation. And consumer-wearable activity trackers have possibility conveniently and rationally to evaluate these disabilities in PD patients. However, most of released consumer-wearable activity trackers are made for sports activity and are hardly to detect slow movement dominantly observed in PD patients [14].

Although growing amount of consumer-wearable activity trackers have been sold in consumer market, about the reasons why described in text, we selected Fitbit. Why was Fitbit suitable for evaluating PD patients? Pradhan [17] suggested that PD patients had reduced quantity and intensity of physical activities compared to healthy older adults, so the consumer-wearable activity trackers should have ability to detect small amount and low intensity activities of physical activities. Fitbit has such a character.

Mechanism of Fitbit to track health metrics.

In Fitbit Health Solutions, they [16] note that Fitbit offers devices that track a variety of metrics, including step count, floors climbed, distance, calories burned, active minutes, sleep time and stages, and heart rate.

To determine subject's heart rate, the optical heart-rate sensor in the Fitbit device flashes its green LEDs many times per second and uses light-sensitive photodiodes to detect these capillary volume changes in the capillaries above the wrist. Then, the device calculates how many times subject's heartbeats are per minute (bpm).

Fitbit devices use a 3-axis accelerometer to count steps. This sensor also allows the device to determine the frequency, duration, intensity, and patterns of movement (Figure 1).
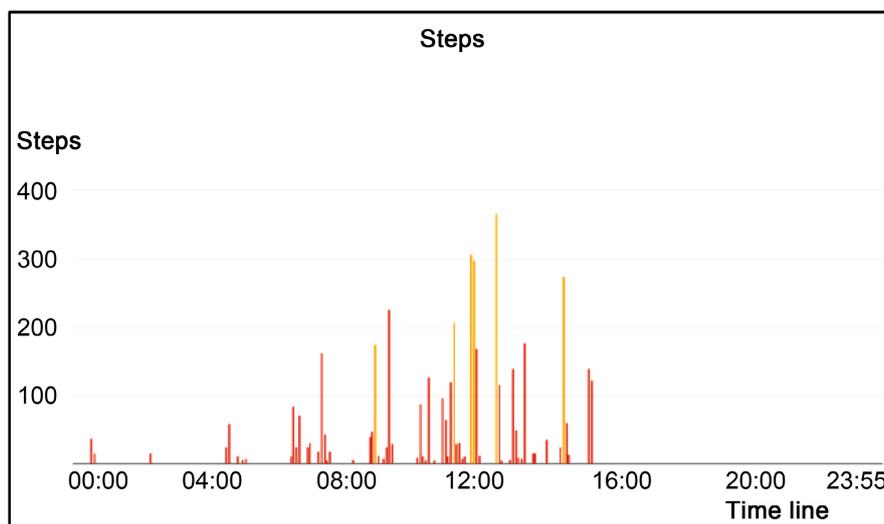
Figure 1. Steps detected by Fitbit. The vertical axis stands for number steps per minute and the horizontal axis stands for time line.

Fitbit devices combine subject's basal metabolic rate (BMR) and activity data to estimate calories burned. Adding heart-rate data can estimate calories burned during exercise.

Fitbit estimates subject's sleep stages using a combination of movement and heart rate patterns. When subject haven't moved for about an hour, tracker or watch assumes that subject is asleep. Additional data—such as the length of time subject's movements are indicative of sleep behavior (such as rolling over, etc.) help confirm that subject is asleep. While sleeping, subject's device tracks the beat-to-beat changes in heart rate, known as heart rate variability (HRV), which fluctuate as subject transition between light sleep, deep sleep, and REM sleep stages (Figure 2).

In this mini review, we summarize the evidence for validity of the most popular consumer-wearable activity tracker (Fitbit) to estimate the amount of physical activity, physical activity energy expenditure, and quality of sleep in Parkinson's disease.

2. Methods

We researched full-length English studies in PubMed, Science Direct, Google Scholar, and Scopus, through September, 2021.

3. Results

In total, 27 studies and a textbook description [16] were included in the review.

To adapt consumer-wearable activity trackers for evaluating health-related metrics in Parkinson's disease (PD) patients, there may be some points to be elucidated and conquered. First, measurement accuracy and precision are required. Second, inter-device reliability for measuring steps, distance, and energy expenditure must be considered. Third, wearability; there are some types of
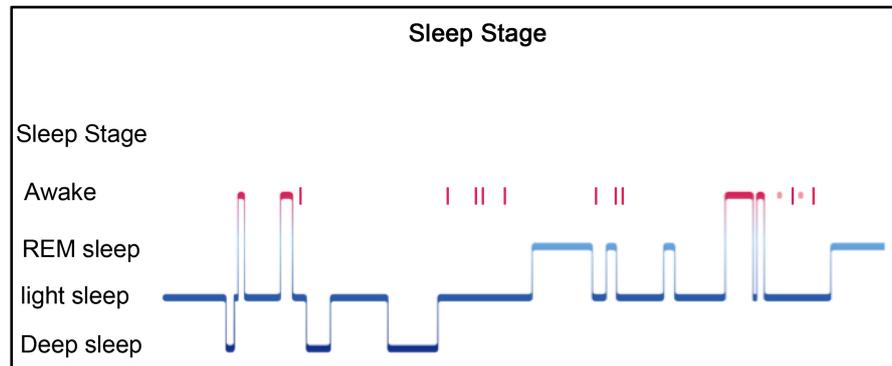
Figure 2. Sleep stages detected by Fitbit. The vertical axis stands for sleep stage and the horizontal axis stands for time line.

device such as wrist-worn, ankle-worn, belt-fixed, and so on [17].

Evenson [14] summarized the evidence for validity and reliability of Fitbit and Jawbone and their ability to estimate steps, distance, physical activity, energy expenditure, and sleep. Evenson pointed that Fitbit had tendency to over-estimate at slower speeds and to under-estimate at faster speeds. This superficial weakness of Fitbit is conversely advantage to detect slow movements in PD. Measurement of energy consumption was tended to under-estimate by either device. Total sleep time and sleep efficiency were over-estimated and wake after sleep onset was under-estimated comparing metrics from polysomnography to either tracker. Paul [18] studied to determine the criterion validity of Fitbit step counts compared to visual count and ActiGraph accelerometer step counts in community-dwelling older people during a 2 min walk test (2 MWT). Their results indicated that percentage agreement was closest for Fitbit steps compared to visual count and least for Fitbit average steps/day compared to the ActiGraph. They concluded that Fitbit is sufficiently accurate to be used among community-dwelling older adults to monitor and give feedback on step counts. Price [19] estimated energy expenditure data measurement from four consumer-wearable activity trackers and compared to measurement from indirect calorimetry. In their study energy expenditure estimates from the Fitbit correlated significantly with calorimetry across all gait speeds but did not with calorimetry across running speeds. Murakami [20] [21] examined the validity of total energy expenditure estimated by 12 consumer-wearable activity trackers during 1 standardized day in a metabolic chamber and 15 free-living days using the doubly labeled water method. They concluded that accurate estimations of the net physical activity energy expenditure using consumer-wearable activity trackers are required.

Kim [22] raised a question that wrist monitors were likely to overestimate activity; however, they used ActiGraph accelerometers, not consumer-based wearable devises. Pradhan [15] pointed wrist wearable devises had enough ability to detect steps and physical activities. Wendel [23] described that waist-worn activity trackers might monitor continuous walking with reasonable accuracy comparing with wrist-worn ones. Larmont [24] compared Fitbit with the other de-

vice and Fitbit had advantage in independency of intensity of activity and concluded that these wrist-worn devices might be a clinically useful adjunct to exercise therapy to increase physical activity in people with PD.

Xue [25] raised possibility of detecting nocturnal hypokinesia in PD using multisite inertial sensors. De Zambotti [9] evaluated the performance of Fitbit, against polysomnography (PSG) and concluded that Fitbit showed promise in detecting sleep-wake states and sleep stage composition relative to gold standard PSG, particularly in the estimation of REM sleep. Non-motor symptoms especially sleep disturbances, along with motor symptoms can be biomarkers to predict PD development [26].

Only evaluated ability to detect steps, physical activities and energy expenditures, but some authors raised applicability of consumer-based wearable devises for evaluating treatment effect in PD patients. Alley [27] using The Timed Up and Go test (TUG) suggested possibility to measure individual mobility in PD patients. Kleiner [28] tested a wearable device and showed excellent reliability, accuracy and precision in quantifying total TUG test duration. Since TUG is a widely used test in rehabilitation settings, its automatic quantification could potentially improve the quality of assessments in the quantification of PD gait ability [29]. Lai [30] comparatively evaluated three consumer-grade motion sensors in measuring steps with over ground and treadmill walking in PD and concluded that the waist-worn sensor (Fitbit One) was accurate and precise. Suppa [31] or Pulliam [32] assessed levodopa response in PD with wearable systems and availed comprehensive results. Colón-Semenza [33] developed a remote peer coaching using Fitbit and concluded that was feasible, safe, and acceptable for PD patients. However, as Alley [27] described that the lack of web-based physical activity interventions for the older may be due to the stereotype that older adults are low internet users and therefore do not engage in web-based health program. Mercer [34] compared four consumer-wearable activity trackers (Fitbit Zip, Misct Shine, Jawbone Up 24, and Withings Pulse) and asked which device was preferable. Preferences varied but 50% felt they would buy a Fitbit and 42% felt they would buy a Misct, Jawbone, or Withings. This suggests Fitbit may be acceptable device for older adults. To improve usability, older users may be select from devices that have better compatibility with personal computers or less-expensive Android mobile phones or iPhone and tablets. And they prefer devices with comprehensive paper-based user manuals and with applications that interpret user data. PD patients may unfamiliar with IoT and may need support to both set up the device and learn how to interpret their data. Wrist-worn wearable activity trackers including Fitbit can fulfill their requirement.

4. Discussion

During a standard clinical evaluation, patient's motor symptoms are visually assessed by clinicians while the individual performs specific tasks such as holding their arms outstretched, tapping their fingers, or tapping their toes [13]. Mea-

suring PD symptoms during activities of daily living create an entirely new set of challenges for wearable sensors and algorithms. Not only must the system be intelligent enough to detect symptoms and side effects, but also it must be able to distinguish those from activities of daily living [35] [36] [37] [38] [39]. This comment is hallmark of assessment PD patient's motor and nonmotor signs and symptoms by using consumer-wearable activity trackers.

Motion sensors are common today in wearables, watches, and mobile devices for monitoring exercise or general step counts. These gross measures of movement, however, do not provide a direct measure of PD features such as tremor, bradykinesia, or dyskinesia, as each of those symptoms have very distinct features and determine PD diagnosis. Actually, Apple watch got US patent (US number 20190365286) for providing continuous monitoring of dyskinesia and tremors, which could help clinicians, treat PD better. Apple's claims that dyskinesia and tremors tend to occur when all of the other features of PD are being well managed through medication. Bai [40] [41] compared Apple Watch with Fitbit. Apple Watch had an advantage in detecting heart rate in aerobic exercise, but PD patients tended to show slow activities. However, since different devices have different measurement characteristics, a lack of standardization with accelerometry-based monitors has made it hard to advance applications for both research and practice. Consensus guidelines are needed for clinical application of consumer-wearable activity trackers.

Continuous and objective monitoring of motor and non-motor symptoms is needed to complement clinical assessments and patient reported outcomes. Such consumer-wearable activity trackers with rational algorithm could offer an objective measure for PD diagnosis and symptoms assessment, provide patients with a tool to monitor and track their disease, and give physicians a more thorough understanding of experience with PD patients, outside the clinic.

5. Conclusion

This mini review indicated Fitbit could estimate the amount of step, physical activity, physical activity energy expenditure, and quality of sleep in PD patients. As new activity trackers and features have been introduced to the market, documentation of the measurement properties can guide their use in PD research settings. And physical activities may also improve quality of life in PD patients.

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Conflicts of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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