

Preventing Physical Inactivity during Future Pandemics

Subjects: Primary Health Care

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Wearable activity trackers are devices that are comfortably worn on the body and are designed to be effective in monitoring daily physical activity and improving physical fitness of the wearer. This review aimed to investigate the impact of the coronavirus disease 2019 (COVID-19) pandemic on physical activity measured using wearable activity trackers and discuss future perspectives on wearable activity trackers during pandemics. Daily physical activity was significantly decreased during the COVID-19 pandemic.

Keywords: wearable device ; smartphone application ; telemedicine ; physical activity ; COVID-19

1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has emerged and become prolonged, significantly affecting the lives of people worldwide. To date (September 2021), over 220,000,000 coronavirus cases and 4,500,000 deaths due to COVID-19 have been confirmed across the globe ^[1]. New coronavirus variants have been appearing one after another, and some mutated strains, such as the Delta variant, may be more contagious, virulent, and vaccine-resistant, which will make it difficult for humans to manage the pandemic effectively ^[2]. Several countries took non-pharmaceutical public health measures such as lockdown ^[3] and social distancing ^[4] in addition to conventional infection control measures (e.g., handwashing and wearing of face masks); however, the spread of COVID-19 is not currently controlled. People are required to make behavioral and lifestyle changes in this pandemic era. The development of technologies and systems that enable disease prevention, effective healthcare without a risk of infection, and protection of human life is critical ^[5].

Wearable devices that can comfortably be worn on the body and perform several tasks in conjunction with handheld devices, such as smartphones, play a pivotal role in healthcare ^[6]. Recent systematic reviews have shown that wearable devices are useful for monitoring heart rate and sleep in hospital settings ^[7], increasing physical activity in children and adolescents ^[8], improving health-related outcomes in patients with cancer ^[9], and reducing body weight in individuals with obesity ^[10]. In addition, during the COVID-19 pandemic, sleep pattern and duration were accurately and effectively monitored by wearable devices ^{[11][12][13][14][15]}. On the other hand, social distancing or self-isolation can decrease daily physical activity ^[16], and such physical inactivity may increase cardiovascular risks ^[17]; further, physical inactivity itself was associated with an increased risk of hospitalization due to COVID-19 (relative risk = 1.32; 95% confidence interval [CI], 1.10–1.58) ^[18]. Physical inactivity is a global health problem responsible for the increasing risk of noncommunicable diseases, such as diabetes, coronary heart disease, and breast and colon cancers, and Lee et al. ^[19] reported that the life expectancy of humans would increase by 0.68 years by increasing physical activity. Promoting and increasing physical activity are the cornerstone of the management of diabetes and obesity, which are now the risks of severe COVID-19 as well as public health epidemics.

2. Physical Activity during the COVID-19 Pandemic

In this narrative review, the author focuses on the impact of the COVID-19 pandemic on physical activity measured using wearable activity trackers. The author performed a literature search on COVID-19 and wearable devices in PubMed. The search terms were “COVID-19” and “wearable”. The titles and abstracts of the identified articles were reviewed to determine their relevance. The author excluded editorials, commentaries, and letters. The search of PubMed from its inception to August 2021 yielded 253 articles. Of these, nine studies were included in this review (**Figure 1**).

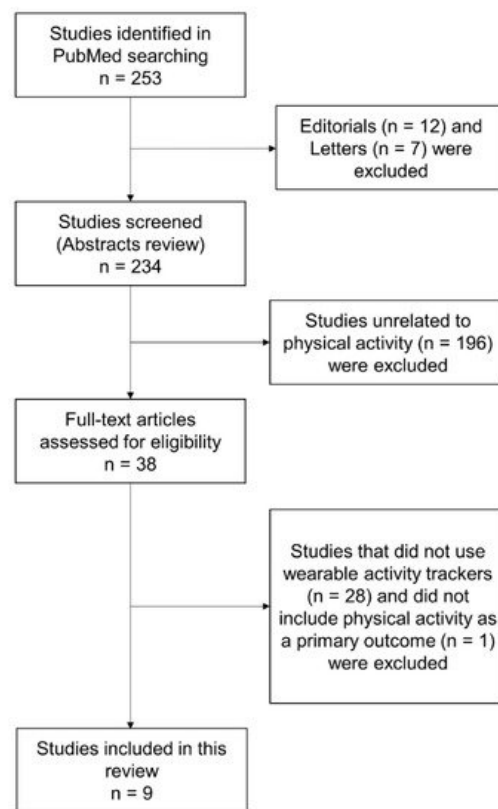


Figure 1. Review flow chart.

The Remote Assessment of Disease and Relapse–Central Nervous System (RADAR-CNS) Consortium reported that people in Italy, Spain, Denmark, the United Kingdom (UK), and the Netherlands significantly changed their behavior during the COVID-19 pandemic based on the data from wearables and mobile technologies [20]. A total of 1062 subjects were recruited in the RADAR-CNS study, and the following data were collected through a smartphone or a Fitbit device on a 24/7 basis: smartphone location (maximum traveled distance from home and homestay), smartphone Bluetooth (maximum number of nearby devices), Fitbit step count, Fitbit sleep (bedtime and sleep duration), Fitbit heart rate (average heart rate), smartphone user interaction (unlock duration), and smartphone use event (social application use duration). Subjects spent more time on social media (Italy, Spain, the UK, and The Netherlands), had a lower heart rate (Italy, Spain, and Denmark), slept later (Italy, Spain, the UK, and The Netherlands), and slept longer (Italy, Spain, and the UK) during the lockdown than before the lockdown. Young subjects (<45 years) also had fewer daily steps during the lockdown than before the lockdown (Italy, the UK, and The Netherlands). Subjects whose body mass index (BMI) was less than 25 kg/m² walked more than subjects with a high BMI (≥25 kg/m²). Non-pharmaceutical measures such as lockdown made people inactive, and the health of people with overweight/obesity could be damaged more by lockdown than people with normal weight. Interestingly, there were different results across countries; for example, Denmark showed small behavioral changes in response to the lockdown. Apart from the effectiveness of lockdown for infection control during the pandemic, young people with obesity should be monitored carefully to prevent health problems due to physical inactivity when implementing lockdown and social distancing. Importantly, obesity is significantly associated with the increased risk of susceptibility to COVID-19 (odds ratio (OR), 2.42; 95% CI, 1.58–3.70), severity of COVID-19 (OR, 1.62; 95% CI, 1.48–1.76), hospitalization (OR, 1.75; 95% CI, 1.47–2.09), and death (OR, 1.23; 95% CI, 1.06–1.41) [21].

A small retrospective observational study in Poland showed similar results [22]. Five subjects who self-isolated at home during the COVID-19 pandemic were enrolled in this study, and their daily steps, resting heart rate, and sleep duration were recorded for 464 days. The data were collected through Fitbit Versa smartwatches. The self-isolation period was 50 days. The daily step count (from 7550 ± 4430 to 3230 ± 1910 steps) and resting heart rate (from 63.28 ± 4.36 to 60.23 ± 3.69 beats per minute (bpm)) were significantly decreased during the self-isolation period compared with those before the lockdown, but no significant change was noted in sleep duration. However, sleep duration (from 429.64 ± 66.80 to 371.73 ± 117.19 min) was significantly decreased in subjects aged ≥80 years during the self-isolation period. The cardiovascular and pre-frailty risk assessment score using age, daily steps, resting heart rate, and sleep duration was developed in this study; four out of five subjects increased the score during the self-isolation period, and two out of five subjects were considered to have an increased cardiovascular and pre-frailty risk due to self-isolation. This study suggests that self-isolation is harmful for physical health and increases the risk of cardiovascular disease and frailty. The authors undoubtedly expect that smartwatches or other medical wearables will play an essential role in telemedicine when a public health emergency, such as a pandemic, occurs.

Taylor et al. [23] quantified the effect of lockdown on physical activity in patients with heart failure. Physical activity data were collected from modern cardiac implantable electronic devices (CIEDs) in the Triage HF Plus Evaluation Study in the UK. CIEDs have multiple built-in sensors to monitor real-time physiological data including physical activity, thoracic impedance, heart rate, heart rhythm, and atrial arrhythmias. A total of 311 patients who completed the collection of 8-week activity data (pre-lockdown for 4 weeks and post-lockdown for 4 weeks) were enrolled in this study. Daily physical activity was measured by an accelerometer within the CIED. A total of 246 patients (79.1%) showed a reduction in physical activity post-lockdown. The median physical activity per day was significantly decreased from 134.7 min/day during pre-lockdown to 113.9 min/day during post-lockdown. Daily physical activity was immediately decreased within 2 weeks after the implementation of lockdown. There were no characteristics of patients such as age, sex, BMI, frailty, and severity of heart failure that were clearly associated with the reduction in physical activity due to the lockdown. **Table 1** summarizes the studies investigating the change in daily physical activity during the COVID-19 pandemic.

Table 1. Changes in daily physical activity measured by wearable activity trackers during the COVID-19 pandemic.

Authors, Year	Subjects Countries	Study Design Study Period	Wearable Activity Trackers	Results
Sun et al., 2020 [20]	1062 patients with major depressive disorder or multiple sclerosis in Italy, Spain, Denmark, the United Kingdom, and Netherlands Age: No description BMI: No description	Prospective cohort study a part of the RADAR-CNS studies Between 1 February 2019 and 5 July 2020	Smartphone Fitbit	Daily step count↓ in young subjects Heart rate↓ Time spent on social media↑ Sleep duration↑
Kańtoch E and Kańtoch A, 2021 [22]	5 adult volunteers (2 men and 3 women, 2 subjects with history of cardiovascular diseases) Poland Age: 57 ± 22.38 years BMI: 27.80 ± 2.95 kg/m ²	Retrospective observational study Between 22 January 2019 and 30 April 2020	Fitbit Versa smartwatch	Daily step count↓ Resting heart rate↓ Sleep duration →
Mishra et al., 2021 [24]	10 community-dwelling older adults (6 men and 4 women) United States Age: 77.3 ± 1.9 years BMI: 27.5 ± 1.6 kg/m ²	Prospective observational study Between January–March 2020 and March–September 2020	ActivePERS/PAMSys pendant	Daily step count↓ Standing%↓ Walking%↓ Sitting%↑ Sleep quality →
Woodruff et al., 2021 [25]	121 subjects (23 men, 96 women, 1 cisgender, and 1 unknown) Canada Age: 36.2 ± 13.12 years BMI: No description	Prospective observational study Between March 2020 and April 2020	Various activity trackers, e.g., Apple Watch, Fitbit, Samsung, and Garmin	Daily step count↓ Sedentary time↑
Ong et al., 2021 [26]	1824 city-dwelling, working adults (883 men and 941 women) Singapore Age: 30.94 ± 4.62 years BMI: No description	Prospective cohort study Between 2 January 2020 and 27 April 2020	Fitbit	Daily step count↓ Time spent on moderate-to-vigorous activity↓ Resting heart rate↓ Sleep duration↑ Sleep efficiency →
Pépin et al., 2020 [27]	Approximately 742,000 individuals using wearable activity trackers (proportion of women: 37.8%) Australia, Canada, China, France, Germany, Ireland, Italy, Japan, Netherlands, Singapore, Switzerland, United Kingdom, and United States Age: 35–46 years BMI: No description	Retrospective observational study Between 1 December 2019 and 13 April 2020	Withings	The number of steps↓ in countries with lockdown The number of steps↑ in Sweden without lockdown

Authors, Year	Subjects Countries	Study Design Study Period	Wearable Activity Trackers	Results
Capodilupo and Miller, 2021 [28]	5436 individuals using a wearable activity tracker (3900 men and 1536 women) United States Age: 40.25 ± 11.33 years BMI: No description	Retrospective observational study Between 1 January 2020 and 15 May 2020	WHOOP strap	Exercise frequency↑ in all subjects Exercise frequency↓ in subjects aged 18–25 years Resting heart rate↓ Heart rate variability↑ Sleep duration↑
Zinner et al., 2020 [29]	14 highly trained athletes (6 men and 8 women) Germany Age: 17.1 ± 1.9 years BMI: 22.9 ± 1.4 kg/m ²	Retrospective observational study During 4 weeks prior to and after the social distancing and lockdown on 23 March 2020	Polar M430	Training time↓ Time spent on light- and moderate-intensity physical activity↓ Sitting time↓ Time spent lying down↑
Taylor et al., 2021 [23]	311 patients with heart failure (240 men and 71 women) United Kingdom Age: 68.8 years BMI: <18.5 kg/m ² (0.7%), 18.5–24.9 kg/m ² (22.3%), 25–29.9 kg/m ² (32.8%), >30 (44.3%)	Prospective observational study During 4 weeks preceding and following the lockdown on 23 March 2020	Triage HF	Daily physical activity↓

↑, increase; ↓, decrease; BMI, body mass index; RADAR-CNS, Remote Assessment of Disease and Relapse–Central Nervous System.

It is evident that there is heterogeneity among the studies. First, the types of wearable activity trackers differ among the studies. Although there is evidence supporting inter-device validity and reliability between different types of wearable activity trackers [30], the method for measuring physical activity should be standardized. Henriksen et al. [31] developed a system to record data on physical activity from different types of wearable activity trackers (Apple, Fitbit, Garmin, Oura, Polar, Samsung, and Withings) and confirmed that there was a significant reduction in the daily step count and energy expenditure during the lockdown period. However, the development of a more accurate and more reliable device is a challenge for the future. Second, there is a lack of information on the characteristics of subjects in the included studies. For example, five of nine studies do not show the BMI of the study subjects. In addition, most of the study subjects are probably healthy in the large-scale studies [20][26][27][28]; however, it is possible that those studies include subjects with chronic diseases, and the impact of the pandemic on daily physical activity differs between healthy individuals and patients with chronic diseases. Further studies assessing the change in daily physical activity in patients with chronic diseases such as diabetes, chronic kidney disease, and cancers during pandemics are warranted.

3. Conclusions

In conclusion, daily physical activity was significantly decreased during the current COVID-19 pandemic. It depends on the types of non-pharmacological public health measure; however, the reduction in daily physical activity reaches approximately 10–50% of the amount of daily physical activity before the pandemic. After the current pandemic, the world may confront a significant increase in the number of individuals with metabolic disturbances, such as obesity and diabetes. It should be considered that healthcare professionals encourage people to increase (or at least maintain) daily physical activity via wearable technologies such as smartphone applications. If we construct an effective healthcare system involving wearable activity trackers, we will be able to prevent health problems due to physical inactivity and hospitals' burden during pandemics in the future.

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