Utility of Fitbit devices among children and adolescents with chronic health conditions: a scoping review

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Background: While Fitbit® devices were initially intended for leisurely, consumer use, there has been recent interest among scientific and medical communities in the prospective use of Fitbit devices for clinical and research purposes. Those who have chronic health conditions are often required to spend considerable amounts of money and time undergoing physiological tests and activity monitoring to support, stabilize, and manage their health. This disease burden is only amplified in pediatric populations. Devices that are used to collect these data can be invasive, uncomfortable, and disconcerting. Using the Fitbit tracker to acquire such biometric data could ease this burden. Our scoping review seeks to summarize the research that has been conducted on the utilization of Fitbit devices in studies of children and adolescents with chronic health conditions and the feasibility, accuracy, and potential benefits of doing so.

Methods: Searches were conducted on PubMed for articles relating pediatric health to Fitbit device usage (using a Boolean search strategy). The eligibility criteria included trials being clinical and/or randomized controlled and articles being in English. Once articles were obtained, they underwent screening and exclusion processes and were charted for their titles, authors, objectives, results, and respective chronic illnesses. In the subsequent full-text review, further charting was conducted, collecting study designs, Fitbit parameters, feasibility, accuracy, and related health and clinical outcomes.

Results: Fitbit trackers were unanimously demonstrated to be feasible devices in this population for physical activity monitoring and were determined to be potentially beneficial in measuring and improving overall wellbeing and physical health in children with chronic illness. Nevertheless, sufficient evidence was not found in support of Fitbit accuracy. Additional biases were identified against the population of children with chronic health conditions that may further enable inaccurate data.

Conclusions: While Fitbit devices may be beneficial for those interested in improving physical health, discretion is advised for those seeking to collect accurate and/or medically necessitated data. Given the existing literature evaluated, medical-grade technologies are preferred in instances of the latter, as Fitbit devices have not been found to provide reliably accurate data.

Keywords: Fitbit; children; chronic health conditions; physical activity; clinical outcomes

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Introduction

Chronic health conditions in children and youth have become increasingly prevalent over the past half century, resulting from a variety of etiologies including perinatal changes in mothers, children's diets, increases in sedentary leisure activities (such as television and video games), and generalized environmental changes (1). Definitions of chronic health conditions are varied, however for the purposes of our study, we will utilize that of the World Health Organization. They define chronic health conditions as non-communicable diseases (NCDs), or those that "tend to be of long duration and are the result of a combination of genetic, physiological, environmental, and behavioral factors. The main types of NCD are cardiovascular diseases (such as heart attacks and stroke), cancers, chronic respiratory conditions (such as chronic obstructive pulmonary disease and asthma and diabetes)" (2). In 1960, just 1.8% of children had a health condition that impacted daily living (3); this soared to greater than 8% in 2010 (4), representing a 400% increase in chronic health conditions in children (particularly asthma, mental health conditions, obesity, and neurodevelopmental disorders) (5). This remarkable increase in the prevalence of chronic health conditions is multifactorial and is likely due to scientific advances in widely available diagnostic tools. Although children suffering from chronic illnesses have been found to have worse overall health than peers without such conditions, recent research has demonstrated similar levels of general life satisfaction across both pediatric groups (6). This, however, is not true for health-related quality of life (HRQOL). A study of children with prevailing chronic health conditions [asthma, eczema, dyslexia, attention-deficit hyperactivity disorder (ADHD), and migraines] were demonstrated to have lower HRQOL than children without chronic illness (7). Moreover, children with chronic diseases have an increased risk of anxiety and depression (8). These diseases affect not only children themselves, but also their families. Parents of children with chronic diseases have been found to more frequently suffer from anxiety and depression, and those with children having congenital diseases saw increased risks of cardiovascular diseases and mortality (9).

To study and improve physical health in children with chronic illnesses, interventions and health management programs have been implemented and researched. Given that overall health of children with chronic illnesses is worse than that of their peers, many studies have utilized measures of physical health (such as steps taken, calories burned, heart rate, etc.) as markers of health in children with chronic health conditions (10). For this reason, and because a direct relationship has been found between increased physical activity and improved HRQOL in children and adolescents with chronic diseases (7), researchers have implemented interventions to improve children's physical health. Some have been purely family-based (11) while others are school-based (12). In our paper, we consider another type of intervention for children with chronic health conditions: technology-based—specifically the use of Fitbit devices. Family- and education-based interventions have been successful in improving health because they function within children's mainstays: school and home. However, with increased technological literacy among children and young people, technology (solely and in conjunction with other interventions) is being examined for future use in pediatric healthcare; this would not only bring a sense of familiarity, but also comfort and empowerment.

There is a potential for consumer wearable devices (such as those made by Fitbit) to be useful in future clinical practice, given technological advancements and the growing popularity of individualized health programs (10). Research has been conducted on the feasibility and means of developing medical-grade wearable devices to monitor vital signs (13), and wearable devices have in turn been demonstrated to be feasible for monitoring physical activity in children with chronic conditions (14). In adults with chronic conditions, commercial wearable technology has been reported to be beneficial as a motivator and for increasing physical activity (15), but health outcomes related to respective chronic illnesses have yet to be found (16). Among wearable technology brands, Fitbit has been studied the most frequently (17), guiding its selection for further research in this paper. In spite of demonstrated potential for improving health outcomes in children with chronic conditions (18,19), discrepancies exist within the body of research on Fitbit wearables regarding their accuracy and validity as measurement devices. For the purposes of this review, the terms "health outcomes" and "clinical outcomes" will be used interchangeably, and they will be regarded as "measurable changes in health, function or quality of life" (20). While some studies have demonstrated the reliability of Fitbit trackers in monitoring children's activity (21-24), others have shown that Fitbit devices can be inaccurate (25). There has also been an increased interest in alternative, remote means of health management, given that methods of monitoring health in children are

Table 1 Search terms used for scoping review search on PubMed

"adolescent" AND "Fitbit"
"child" AND "Fitbit"
"children" AND "Fitbit"
"pediatric" AND "Fitbit"
"teen" AND "Fitbit"
"teenager" AND "Fitbit"

often invasive, uncomfortable, and expensive (26). Both in design and public perception, Fitbit devices overcome these barriers to care and may further benefit their users in medical circumstances by providing immediate health data to individuals and empowering young people to understand, manage, and improve their health.

Our review contributes to the literature as the first scoping review—to our knowledge—to characterize and evaluate the body of existing literature regarding the use of Fitbit devices in children with chronic health conditions in such a comprehensive analysis (assessing accuracy, feasibility, feedback, and clinical/health outcomes). The primary aims of this study are thus to survey relevant studies about Fitbit devices and establish further points of analysis using trends in collected data. These have been identified as (I) studies' objectives and methods in relation to utilizing Fitbit devices, (II) the accuracy, acceptability, feasibility, and advantages/disadvantages of Fitbit devices, and (III) clinical and health outcomes related to using Fitbit devices. The assessment of these three points regarding Fitbit use will lead to some determination of how Fitbit trackers could and should be utilized by children with chronic health conditions, whether in clinical or recreational settings. This research may be additionally beneficial in identifying gaps in the existing research on the use of Fitbit devices in children. We present the following article in accordance with the PRISMA-ScR reporting checklist (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-21-28/rc).

Methods

There was no protocol for this review, nor is this scoping review registered. The methodology for data collection was adapted from "Guidance for conducting systematic scoping reviews" from the Joanna Briggs Institute (27). Searches for articles to be included in our study were conducted from November 27, 2020 to December 28, 2020 using PubMed and a Boolean search strategy with the operator "AND". This was done to ensure that the data search included solely articles relevant to our inclusion criteria. The specific search terms utilized to identify articles relating Fitbit use and pediatric populations can be found in *Table 1*. Eligibility criteria included journal articles being clinical and/or randomized controlled trials and the publication language being English. No exclusions were implemented based on publication status nor year of publication; while publication year restrictions are typically incorporated to ensure research relevance/accuracy, it is by nature of the scoping review to evaluate the entire relevant body of literature. Thus, all publication years were considered. The titles, authors, objectives, and results of identified articles were charted onto an Excel spreadsheet. It was soon noted that many articles related to a chronic illness, so this was also charted for each article and added to the inclusion criteria. The list of articles was screened for duplicates, which were removed. Each article was then downloaded in full-text form to be assessed and filtered for inclusion using the inclusion criteria. This article selection process is visualized in further detail in *Figure 1*.

The inclusion criteria for our study required that articles must have studied (I) explicitly pediatric populations (mean age <24), (II) those with a chronic illness, and (III) populations that wore some Fitbit device for some duration during the study. The participant age range included in this review is in accordance with the World Health Organization and the United Nations, who have termed "young people" as up to 24 years of age (28). Any papers not meeting all three criteria were excluded. The remaining full-text articles were then read and charted in greater detail, assessing for key information including study design, Fitbit feasibility and accuracy, and health/clinical outcomes of Fitbit use (*Table 2*). The article search, collection, filtering, data extraction, and data collection were carried out by the first author under supervision of the corresponding author. This single reviewer process reduced bias by eliminating concern for inter-rater reliability.

Results

Twenty-five studies met our criteria of having used a Fitbit device in research of children with chronic health conditions. Within these papers, 11 chronic diseases were studied and/or were incorporated into the research, such as cancer, asthma, congenital heart disease (CHD), and obesity. While each study incorporated Fitbit devices into

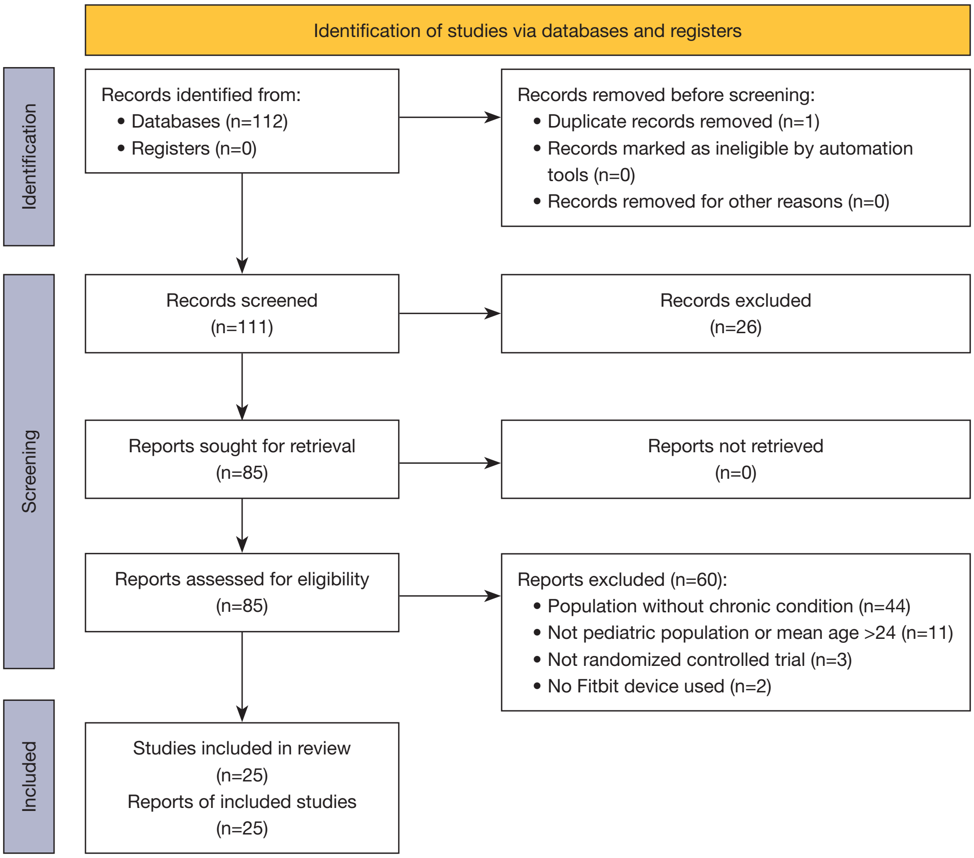

Figure 1 PRISMA flow diagram of article search, exclusion, and extraction process. During screening, studies were excluded if they did not meet inclusion criteria and/or were review articles (most common reasons were the latter and adult populations). During eligibility, articles were excluded if, after full-text-review, they did not meet inclusion criteria.

Table 2 Key data fields collected in the data extraction process

Chronic illness
Objectives/aims
Author(s)
Year of publish
Fitbit parameter(s)
Fitbit accuracy
Study design
Fitbit feasibility/acceptability
Fitbit advantages, disadvantages, and feedback
Activity level changes
Clinical/health outcomes
Fitbit model
Study length
Participants (number, gender, age) (18,19,29-51)

their research for a different reason and collected a different dataset, patterns were identified in studies' research objectives and what they sought to gain from researching or using Fitbit devices.

Study characteristics, objectives, and methodology

The average participant age was 12 years, and the total participant age range was 3–35 (3 studies used participants 21 or older). The number of study participants ranged from 9–180 with an average of 51. Studies on average had a higher percentage of females than males, the average percentage of male participants being 47.3. Study lengths ranged from 1 day to 1 year and averaged at 17 weeks long (*Table 3*).

While a variety of Fitbit products were studied, the Fitbit Flex and other wrist-based models were most common (the Fitbit Zip and One are not wrist-based). Nineteen of the

Table 3 Characteristics of studies examined

Source (chronic illness)	Fitbit model	Study length	Participants	Percent male	Age (years)
Bian *et al.*, 2017 (asthma) (29)	Charge HR	8 weeks	22	55	14–17
Buchele Harris *et al.*, 2015 (ADHD) (47)	Not described	7 weeks	116	49	~10–11
Chen *et al.*, 2017 (obesity) (18)	Flex	6 months	40	58	13–18
DeBoer *et al.*, 2017 (diabetes) (38)	Charge HR	Two 68-h periods	12	50	5–8
Do *et al.*, 2020 (epilepsy) (43)	Flex	16 months	22	45	8–14
Dugger *et al.*, 2020 (obesity) (37)	Charge 2	10 weeks	180	60	Mean 7.9
Hakim *et al.*, 2018 (sleep apnea) (34)	Charge	1 night/participant	22	41	3–18
Hasan *et al.*, 2020 (VTE) (39)	Charge 2	16 weeks	23	48	7–21
Hemphill *et al.*, 2020 (CHD) (46)	Charge 2	8 months	109	N/A	9–16
Hooke *et al.*, 2016 (cancer) (45)	One	25 days	16	31	6–15
Jacobsen *et al.*, 2015 (CHD) (19)	Flex	12 weeks	14	57	8–12
Jaimini *et al.*, 2018 (asthma) (48)	Not described	1 or 3 months	95	N/A	5–17
Kuan *et al.*, 2020 (CHD) (40)	Charge 2	1 year	156	58	9–16
Le *et al.*, 2016 (cancer) (41)	One	6 months	15	33	15–35
Mendoza *et al.*, 2017 (cancer) (35)	Flex	10 weeks	59	41	14–18
Mittlesteadt *et al.*, 2020 (epilepsy) (30)	Charge 2	N/A	40	15	9–20
Ovans *et al.*, 2018 (cancer) (32)	Flex	24 weeks	15	66	7–8
Sala *et al.*, 2019 (cerebral palsy) (31)	Flex, One	1 day	39	59	4–15
Schoenfelder *et al.*, 2015 (ADHD) (49)	Flex	4 weeks	11	46	14–18
Shelley *et al.*, 2018 (cystic fibrosis) (36)	Flex	N/A	9	44	Mean 12
Turel *et al.*, 2016 (obesity) (50)	Ultra, one	N/A	94	N/A	10–17
van der Kamp *et al.*, 2020 (asthma) (42)	Zip	1 week	30	N/A	4–14
Venkataramanan *et al.*, 2019 (asthma) (51)	Not described	1 or 3 months	83	N/A	5–17
Voss *et al.*, 2017 (CHD) (33)	Charge HR	1 week	30	47	10–18
Yurkiewicz *et al.*, 2018 (cancer) (44)	Not described	1 year	33	42	15–29

ADHD, attention-deficit hyperactivity disorder; CHD, congenital heart disease; VTE, venous thromboembolism.

studies measured steps, 9 collected sleep data, 8 used the distance-traveled metric, 7 collected energy expenditure/calories burned, and 4 collected heart rate data (*Table 4*).

The studies' goals were categorized within three overarching themes (non-mutually exclusive). The first was the intention of using Fitbit trackers to obtain clinical outcomes [in regard to physical and/or mental health (including quality of life)]. These studies typically implemented often-successful interventions with Fitbit devices to achieve desired outcomes. Another common research goal was to uncover physical and psychological effects of the respective chronic illnesses of their participants. The last shared objective was to research the effectiveness, accuracy, and feasibility of utilizing Fitbit devices in disease study and treatment. *Table 5* represents under which theme(s) studies of each chronic health conditions fell, along with the number of studies researching each chronic illness.

The majority of evaluated papers were aimed at utilizing a Fitbit device to assess health related to a chronic illness and/or improve health outcomes for those suffering. Ten studies sought to improve health of children with chronic

Table 4 Objectives, methods, and reported accuracy of Fitbit of studies examined

Source (chronic illness)	Objectives	Fitbit data collected	Fitbit accuracy	Study design
Bian *et al.*, 2017 (asthma) (29)	Explore correlation between self-rated sleep data, Fitbit sleep and PA data, and asthma impact	Steps, calories, distance, heart rate, sleep data (time in bed, awakenings)	Poor long-term sleep and PA accuracy; accurate step accuracy (cited Klassen *et al.*, 2016)	8 weeks wearing Fitbit; questionnaires; monetary compensation
Buchele Harris *et al.*, 2015 (ADHD) (47)	Determine intervention impacts on attention	Steps, calories, distance, heart rate	Not reported	4-week intervention; wore Fitbit, daily 6-minute CBPA break in intervention group; attention tests
Chen *et al.*, 2017 (obesity) (18)	Evaluate intervention effects and feasibility on physical activity	Steps, calories, distance, activity, sleep minutes	Not reported	6 months wearing Fitbit; 3-month intervention program; text messages
DeBoer *et al.*, 2017 (diabetes) (38)	Assess safety and effectiveness of artificial pancreas system	Total steps, steps/min, heart rate	Not reported	Given artificial pancreas system and usual insulin pump/glucose monitor; hypoglycemic events and glucose levels monitored; wore Fitbit
Do *et al.*, 2020 (epilepsy) (43)	Assess sleep quality and relationship between sleep, activity, and psychosocial well-being	Steps/day, sleep efficiency, total sleep time	Sleep overreported	Baseline biometric data collected; questionnaires; 12-week intervention; 16 weeks wearing Fitbit
Dugger *et al.*, 2020 (obesity) (37)	Report obesogenic behaviors leading to BMI increase	Steps, moderate/vigorous physical activity, sedentary time, total sleep, sleep onset and offset time	Reliable and valid for heart rate and sleep (cited de Zambotti *et al.*, 2016 and 2018 and Liang *et al.*, 2018); data comparable to polysomnography	10 weeks wearing Fitbit; either 6-week health/academic program, 4–6 weeks academic program, or no program
Hakim *et al.*, 2018 (sleep apnea) (34)	Compare Fitbit measurements to polysomnography	Total sleep time, total wake time, number awakenings	Total sleep time overestimated; total waking time underestimated	1 night wearing Fitbit during polysomnography
Hasan *et al.*, 2020 (VTE) (39)	Assess adherence to prescribed physical activity after VTE; evaluate QOL and biomarker changes pre- and post-intervention	Steps, distance, active minutes, hourly activity	May underestimate total activity	16 weeks wearing Fitbit; formed physical activity and education groups; PA group had 4 weeks normal PA, 8 weeks coached PA, 4 weeks choice PA
Hemphill *et al.*, 2020 (CHD) (46)	Measure change in physical activity due to COVID-19	Steps	Not reported	Data collected from previously ongoing study; 24 months wearing Fitbit
Hooke *et al.*, 2016 (cancer) (45)	Explore if Fitbit coaching increases steps per day	Steps/day	Not reported	2-week intervention; wore Fitbit and Fitbit coaching; daily emails and Fitbit feedback
Jacobsen *et al.*, 2015 (CHD) (19)	Evaluate feasibility, benefits, and safety of physical activity intervention	Steps	Fitbit data matched daily activity logs	12-week intervention; physical activity program; wore Fitbit; participant and parent surveys
Jaimini *et al.*, 2018 (asthma) (48)	Assess effects of asthma on patients using intervention physiological data	Activity, sleep	Not reported	1- or 3-month intervention; wore Fitbit, Microlife Peak Flow Meter, and Foobot collecting data; mobile app questionnaires

Table 4 (*continued*)

Table 4 (*continued*)

Source (chronic illness)	Objectives	Fitbit data collected	Fitbit accuracy	Study design
Kuan *et al.*, 2020 (CHD) (40)	Evaluate seasonal variation in physical activity	Steps/day	Steps overestimated	1 year wearing Fitbit; wore hip monitor 7 days, physical activity questionnaire
Le *et al.*, 2016 (cancer) (41)	Assess feasibility and health impact of intervention	Steps, calories, distance, overall movement, flights stairs	Not reported	6-month intervention; wore Fitbit daily; surveys and physical evaluations
Mendoza *et al.*, 2017 (cancer) (35)	Promote physical activity in cancer survivors via intervention; assess Fitbit feasibility	Steps, energy expended, distance, minutes of high activity	Not reported	10-week intervention; wore Fitbit, Facebook support group; post-intervention health and feasibility questionnaires
Mittlesteadt *et al.*, 2020 (epilepsy) (30)	Investigate Fitbit ability to detect seizure events	Heart rate	Data collected is second-order; unreliable sleep data; physiological data underestimated (cited Montgomery-Downs *et al.*, 2012 and Benedetto *et al.*, 2018)	Wore Fitbit; compared data to EEG data to assess seizure detection
Ovans *et al.*, 2018 (cancer) (32)	Assess impact of intervention on physical activity, quality of life, and fatigue	Steps/day	Accurate and reliable physical activity tracking (cited Diaz et al, 2015)	12-week intervention; wore Fitbit; physical therapy sessions
Sala *et al.*, 2019 (cerebral palsy) (31)	Assess Fitbit accuracy in ambulation (wrist and hip)	Steps, distance	Wrist Fitbit steps inaccurate, hip Fitbit steps accurate	Wore Fitbit on wrist and hip; stood for 3 minutes, ambulated, sat for 3 minutes
Schoenfelder *et al.*, 2015 (ADHD) (49)	Assess intervention feasibility/ acceptability	Steps, energy expended, distance	Accurate step measurements (cited Evenson *et al.*)	4 weeks wearing Fitbit; joined Facebook group; text messages and questionnaires
Shelley *et al.*, 2018 (cystic fibrosis) (36)	Explore physical activity perceptions and assess Fitbit acceptability	Not reported	Not reported	Wore Fitbit; interviews
Turel *et al.*, 2016 (obesity) (50)	Examine association between obesity and cardiometabolic deficit to suggest intervention(s)	Sleep duration, time asleep, time awake	Sleep duration accurate	Surveys; wore Fitbit; blood test; studied Fitbit sleep measurement validity
van der Kamp *et al.*, 2020 (asthma) (42)	Assess daily physical activity in children with exercise-induced bronchoconstriction	Steps, minutes in different activity intensities	Possible inexactness due to infrequent collection rate	1 week wearing Fitbit; daily questionnaires
Venkataramanan *et al.*, 2019 (asthma) (51)	Determine triggers to asthma using intervention physiological data	Activity, sleep	Stated Fitbit reliability	1- or 3-month intervention; wore Fitbit, Microlife Peak Flow Meter, and Foobot collecting data; mobile app questionnaires
Voss *et al.*, 2017 (CHD) (33)	Assess validity of Fitbit data collection compared to ActiGraph	Steps minutes in different activity intensities	Steps accurate; assumed inaccurate distance	Wore ActiGraph for 7 days; wore Fitbit for 7 days; statistical analysis
Yurkiewicz *et al.*, 2018 (cancer) (44)	Investigate effect of wearable devices on health-related quality of life	Steps, calories, sleep	Not reported	6 months wearing Fitbit, pre- and post-wearing surveys

PA, physical activity; ADHD, attention-deficit hyperactivity disorder; CHD, congenital heart disease; BMI, body mass index; QOL, quality of life; VTE, venous thromboembolism.

Table 5 Study objectives as related to respectively researched chronic health conditions

Chronic illness (number of studies evaluated)	Seeking clinical outcome(s)	Exploring disease-related health effects	Researching Fitbit use in disease treatment
ADHD (n=2)	✓		
Asthma (n=4)		✓	✓
Cancer (n=5)	✓		
CP (n=1)			✓
CHD (n=4)	✓	✓	✓
CF (n=1)			✓
Diabetes (n=1)	✓		
Epilepsy (n=2)	✓	✓	✓
Obesity (n=3)	✓	✓	
Sleep apnea (n=1)			✓
VTE (n=1)	✓		

ADHD, attention-deficit hyperactivity disorder; CP, cerebral palsy; CHD, congenital heart disease; CF, cystic fibrosis; VTE, venous thromboembolism.

illnesses, 9 studies' objectives were to evaluate the impacts of such health conditions on health, and 2 studies aimed to do both; this summed to 21 of 25 articles with the goal of evaluating and/or enhancing participant health (the remaining four studies' objectives were to assess Fitbit accuracy). Seventeen of these 21 articles assessed participants' physical activity levels with Fitbit devices and/or attempted to improve physical activity. Of the 17 studies, 8 implemented health-improving interventions. Two additional studies developed interventions to study effects of their respective chronic illness. Thus, in total, 10 of 25 studies utilized interventions in their research (*Table 4*).

Fitbit accuracy, *acceptability*, *feasibility*, *and (dis) advantages*

In addition to using Fitbit wearables to understand and improve the effects of chronic illness on health, the quality of Fitbit trackers and their data collection was assessed for accuracy, feasibility, acceptability, and advantages/disadvantages. Four studies' objectives surrounded this evaluation, and 23 of 25 studies commented on one of these items. Out of the total 15 articles that addressed Fitbit accuracy, 9 claimed or demonstrated that Fitbit devices were inaccurate, 8 stated or cited that Fitbit devices were accurate, and 2 papers demonstrated both inaccuracy and accuracy of Fitbit devices (*Table 4*). In relation to feasibility and acceptability, 13 papers made positive remarks; 9 studies demonstrated that Fitbit trackers were acceptable, and 6 that they were feasible (*Table 4*). Acceptability and feasibility were assessed by screening articles for (I) claims made by authors that Fitbit devices were feasible and/or acceptable and (II) author reports of compliance and/or adherence to wearing them. Nine of 25 studies indicated that Fitbit devices were advantageous, due to being cost-effective (29-33), non-obtrusive/discrete as a measurement device (29,30), accessible/popular (30,33-36), a source of continuous and long-term measurement (29,36,37), and user friendly (33,35). One study further claimed there are no adverse effects of Fitbit devices (32). Nine of 25 studies contrarily discussed disadvantages of Fitbit devices, including not being designed for children (38), being difficult to use (39,40), causing rash and eczema (40), falling off during exercise (41), having limited data collection abilities (30,37,42), and having a likelihood of non-compliance in adolescents (30,33) (*Table 6*).

Six articles provided participant positive feedback on Fitbit use. In terms of device helpfulness, one study found that 100% of participants appreciated Fitbit wearables for their ability to track physical activity, and 88% found the Fitbit helpful for tracking dietary intake (43). Another study's participants said they would recommend Fitbits to fellow survivors (relating to cancer), with 20% recommending use during treatment therapy and 80% post-

Table 6 Feasibility, overall feedback, and outcomes of studies examined

Source (chronic illness)	Demonstrated feasibility and acceptability	Advantages (A), disadvantages (D), feedback (F)	Activity changes	Clinical/health outcomes
Bian *et al.*, 2017 (asthma) (29)	Not reported	A: continuous, non-obstructive, low-cost	No change	Found potential inverse relationship between sleep quality and pediatric asthma impact—means worse sleep greater asthma impact; Fitbit potential to predict asthma symptoms
Buchele Harris *et al.*, 2015 (ADHD) (47)	Not reported	Not reported	Activity increase	Improved processing speed, focused attention, concentration, attention span
Chen *et al.*, 2017 (obesity) (18)	Not reported	F: 91% participants shared Fitbit data with healthcare providers	Activity increase	Improved BMI, diastolic BP, PA, TV/computer time, consumption of fruit, vegetables, soda/sweet drinks, self-efficacy, and dietary self-efficacy; potential to improve health outcomes and reduce obesity/overweightness
DeBoer *et al.*, 2017 (diabetes) (38)	Not reported	D: not designed for children (limitation)	Activity increased with artificial pancreas system	Not reported
Do *et al.*, 2020 (epilepsy) (43)	Feasible	F: 75% used app throughout day, 100% found Fitbit helpful in PA tracking, 88% found Fitbit helpful in diet tracking	Older participants with initially low activity more likely to increase activity	Improved sleep quality; demonstrated children with epilepsy have comparable sleep and activity patterns to children without epilepsy despite reported fatigue/sleep problems
Dugger *et al.*, 2020 (obesity) (37)	Not reported	A: long wear-time; D: consumer device limits data	Activity (sp. MVPA) increase; sedentary time decrease	Decrease in obesogenic behaviors (improved sleep, screen time, diet, PA)
hakim *et al.*, 2018 (sleep apnea) (34)	Not reported	A: accessible	No change	Not reported
Hasan *et al.*, 2020 (VTE) (39)	Not reported	D: hard to use	No change	Improved PTS scores; lower frequency of PTS development; lower QOL
Hemphill *et al.*, 2020 (CHD) (46)	Not reported	Not reported	Activity decrease	Demonstrated possibly detrimental effects of decreased PA in at-risk population; severe impacts dependent on pandemic length; mean steps in 2019/2020 below Canadian national standard
Hooke *et al.*, 2016 (cancer) (45)	Feasible	F: families enjoyed and interested in future purchase	Increased steps per day during intervention	Increased steps associated with decreased fatigue
Jacobsen *et al.*, 2015 (CHD) (19)	Not reported	Not reported	Exercise capacity increase; VO_2max increase	Parents reported improved HRQOL, social, school, psychosocial, and physical function
Jaimini *et al.*, 2018 (asthma) (48)	66% intervention compliance, thus suitable	Not reported	No change	Improved asthma control levels
Kuan *et al.*, 2020 (CHD) (40)	Initially high acceptability; 60% adherence at completion	D: technical difficulties; skin irritations including rash and eczema	No change	Demonstrated PA increase in late spring/autumn, decrease in winter/summer; most common activities were walking and running; 11% participants met PA guidelines
Le *et al.*, 2016 (cancer) (41)	Feasible	D: fell off during exercise; F: suggested better attachment; would recommend Fitbit to survivors; 20% suggested Fitbit use in therapy; 80% after therapy	Increased MVPA by average 50 min/week	Increased number of participants meeting CDC PA recommendations

Table 6 (*continued*)

Table 6 (*continued*)

Source (chronic illness)	Demonstrated feasibility and acceptability	Advantages (A), disadvantages (D), feedback (F)	Activity changes	Clinical/health outcomes
Mendoza *et al.*, 2017 (cancer) (35)	Acceptable	A: popular device, well-designed, affordable, easy, and can set goals	Activity increase	Increased motivation
Mittlesteadt *et al.*, 2020 (epilepsy) (30)	Compliance ensured via monitoring	A: well-known, affordable, discreet; D: syncing issues, non-compliance, wrist too small, second-order data; F: family interest in consumer device to detect seizures	No change	Not reported
Ovans *et al.*, 2018 (cancer) (32)	Intervention feasible	A: no adverse effects, cost-effective	Non-significant increase in average steps	Increased level of perceived wellness; decreased fatigue, increased quality of life
Sala *et al.*, 2019 (cerebral palsy) (31)		A: low-cost	No change	Not reported
Schoenfelder *et al.*, 2015 (ADHD) (49)	Feasible and acceptable, high adherence	Not reported	Activity increase; increase in average steps	Increased awareness of activity and ADHD symptoms; decreased average ADHD symptoms
Shelley *et al.*, 2018 (cystic fibrosis) (36)	Acceptable and compliant	A: feels like regular watch, comfortable, sleek, compliance, continuity, potential activity motivator	No change	Not reported
Turel *et al.*, 2016 (obesity) (50)	Not reported	Not reported	No change	Found negative correlation between videogame addiction and sleep time, negative correlation between low sleep time and obesity; demonstrated obesity correlated to high BP, low HDL's, high triglycerides, high insulin resistance; demonstrated adverse link between health and videogames
van der Kamp *et al.*, 2020 (asthma) (42)	10% participants low compliance	D: low data collection frequency	Found children with EIB have less (intense) activity than those without EIB	Not reported
Venkataramanan *et al.*, 2019 (asthma) (51)	63% intervention adherence	D: low charge could reduce measurements	Sedentary time decrease	Determined asthma triggers were pollen and PM2.5 (particulate matter)
Voss *et al.*, 2017 (CHD) (33)	Feasible and acceptable	A: at-home PA, fashionable, easy use/user-friendly, cost-effective, accessible, wrist-based technology preferred; D: non-compliance with wristwear common in adolescents; made for adults, thus pediatric accuracy unclear	No change	Demonstrated PA guideline to be ~12,500 steps/day; found participant MVPA comparable to national average; demonstrated boys more active than girls
Yurkiewicz *et al.*, 2018 (cancer) (44)	Acceptable	F: 85% enjoyed wearing	Majority felt more active	Increased number of participants meeting CDC PA recommendations

ADHD, attention-deficit hyperactivity disorder; CHD, congenital heart disease; BMI, body mass index; PA, physical activity; PTS, postthrombotic symdrome; QOL, quality of life; MVPA, moderate to vigorous physical activity; VTE, venous thromboembolism; EIB, exercise-induced bronchoconstriction; CDC, Centers for Disease Control and Prevention.

therapy (41). In terms of satisfaction, 85% of participants of one study enjoyed wearing a Fitbit tracker (44). Families of participants were additionally interested in Fitbit devices for personal use (30,45), and some satisfied participants further shared their Fitbit data with their healthcare providers (18). Finally, one study suggested development of better attachment for Fitbit devices to prevent them from falling off (*Table 6*).

Fitbit health and clinical outcomes

Positive changes in participant activity levels were found as a result of Fitbit use. Twelve of the 25 articles reported an activity increase either after the study or after Fitbit use, including one study where participants claimed to have felt more active (44). One study apart from these twelve demonstrated a likelihood of participant activity increase (43). Another article sought out an activity change in its study objective, but such change was not demonstrated (39). Yet, two studies measured a decrease in sedentary time (37,45); one study did find an activity decrease; however, this was hypothesized (46). Additionally, one study found that its participants with a chronic illness had less intense and lower amounts of activity than those without a chronic illness (42) (*Table 6*).

Twelve studies found clinical and health benefits in their participants, as sought out by their study objectives. Of these, four compared measured physical activity levels to national standards, where it was found that two of four participants met recommendations. Three studies additionally found possible correlations between their individualized study parameter(s) and health outcomes, and one study also demonstrated negative health outcomes (39).

Discussion

Twenty-five papers that studied Fitbit use in pediatric populations with a variety of chronic health conditions were identified, each with unique study designs and research objectives. Many of the analyzed studies had research objectives related to using Fitbit devices to improve participant health and gain positive clinical outcomes, the majority of which achieved such goals. The Fitbit was demonstrated to be a feasible device for collecting data in the populations studied. This was supported by participant and family feedback, yet the studies examined presented equal amounts of advantages and disadvantages of Fitbit devices. Despite having mostly positive effects on participants' clinical outcomes, the data collected from these articles indicate that Fitbits are not reliably accurate devices for measuring physiological data. Many Fitbit parameters were reported as accurate in the studies analyzed, and in other reviews beyond the scope of this study (assessing adults); yet, many studies within our dataset (as well as in those beyond) have found otherwise.

Fitbit inaccuracy

Given the data collected, it is not possible to conclude that Fitbit devices are accurate tools for collecting physiological data in children with chronic illnesses. No consensus was drawn by the articles reviewed relating to Fitbit accuracy. 40% claimed accuracy while 60% claimed not; some of these statements were demonstrated as primary findings, and others via citations of prior research. Those claiming accuracy were in physical activity, steps, heart rate, and sleep. It is difficult to confidently know whether claims of accuracy themselves are well-supported, given that some were simply made with neither justification nor citation. This hesitation did not apply for demonstrations of inaccuracy, which were evidence-based. Discrepancies have also been noted in research on Fitbit accuracy in children *without* chronic health conditions. One study of children aged 9–11 showed accuracy of the Fitbit Charge HR for measuring moderate to vigorous physical activity (MVPA) and sleep and inaccuracy for steps, heart rate, and energy expenditure (52). Another study also on children aged 8–12 with the same device demonstrated strong reliability for MVPA as well as sedentary and light-intensity activity, but conversely found that step counts were relatively/slightly inaccurate (53). However, a third study of preschoolers wearing the Fitbit Flex found a low accuracy of MVPA while sedentary activity was accurately measured (54). While these do not represent the body of research on the accuracy of Fitbit devices in pediatric populations, they serve as an exemplar of the disagreements among findings and researchers on this topic.

We acknowledge that these findings on the accuracy of Fitbit trackers differ from those in the larger body of studies of adult populations, many of which have demonstrated stronger evidence supporting Fitbit accuracy. For example, clinical research on adults has demonstrated accuracy in measuring low levels of physical activity and steps in both healthy populations and those suffering from stroke, brain injuries, chronic obstructive pulmonary disease, and Parkinson's disease (55,56). While it is important to recognize that Fitbit devices have been demonstrated to be accurate in other clinical research, it must too be considered that these exist beyond the scope of our paper and are not implicated by the biases present in this review.

What further complicates the study of Fitbit accuracy is the lack of knowledge of Fitbit devices' ability to collect accelerometer data and/or demographic information to project physical activity data (steps, distance, energy expenditure/calories burned, etc.) (53). This is enabled by Fitbit®'s proprietary rights. Still, Fitbit's website provides some basic information on data collection. All Fitbit devices have a triaxial accelerometer to collect step counts as well as to determine length, intensity, and frequency of movements. The calculation of steps then enables the distance traveled metric to be provided, which is a function of steps and stride length (calculated via height and weight). The energy expenditure calculation utilizes one's basal metabolic rate (as a function of height, weight, sex, and age) and physical activity data to project calories burned. Not all Fitbit devices collect heart rate data, but those that do incorporate these measurements to help calculate energy as well (57). Regarding sleep data, Fitbit trackers utilize lack of movement and heart rate variability patterns to determine when one is sleeping and their stage of sleep (58). This mechanistic description of Fitbit devices' measurements is certainly not to scientific standards, nor to those of devices accepted by the medical community for biometric data collection, such as the ActiGraph.

Fitbit feasibility

The term "feasible" was broadly used in these studies across a variety of contexts. Some did so in reference to Fitbit devices' use in clinical trials as a measurement device, and others in terms of wearability for patients/participants. Nevertheless, all studies that evaluated the feasibility and acceptability of Fitbit trackers had unanimous agreement that they were feasible and acceptable. These conclusions were in line with participants' and families' feedback, where participants found Fitbit devices helpful in measuring physical activity and diet tracking, made suggestions to others with their respective chronic illness to utilize Fitbit devices, generally enjoyed their experience wearing them, and even shared their results and data with their providers. In addition to the physical benefits of the Fitbit, many participants experienced perceived benefits of Fitbit use. Perception is important to consider because if those wearing Fitbit trackers were skeptical, they may have experienced decreased effectiveness. Fitbit use has additionally been shown to be perceived as feasible in young adults aged 20–39 (specifically cancer patients) as well as having the potential for promoting physical activity and health improvements (59). This provides promise for the future of Fitbit use in pediatric populations with chronic health conditions, as positive long-term effects, actual and perceived, of Fitbit use have been demonstrated.

Many participants of the studies evaluated in this review also cited affordability, availability, ease of use, non-invasiveness, and continuity of data collection as advantages of Fitbit devices; there is in turn much appeal in wrist-based technologies for those requiring frequent physiological assessments. This is especially true for pediatric populations, where data collection can feel frightening and difficult in hospitals or via invasive techniques. Thus, Fitbit products, if accurate, could enable doing so in comfort. Alternatively, if what patients require is physical health improvement, Fitbit devices have been demonstrated to be an easy and potentially beneficial tool.

Fitbit effects on health

Of the studies that sought to gain clinical outcomes or health information using Fitbit trackers, their goals were unanimously achieved. Such changes were often observed across many aspects of life, such as increases in physical activity and feelings of being active, decreases in sedentary activity, improved HRQOL, and increased motivation. But additionally, outcomes were measured that were specific to respective illnesses, including improved attention (ADHD), improved BMI and decreased obesogenic behaviors (obesity), and improved asthma control (asthma). Health-related information gained through Fitbit use included identifying that participants met national standards for number of daily steps and correlations between certain behaviors/activities and health. This data does not suggest that Fitbit use is correlated with improved health, however Fitbit devices were successful as a motivational tool for health improvement, and, when combined with health-promoting interventions, are likely to have significant and positive effects. Of course, the range of benefits may vary depending on the chronic illness, patient, and/or desired outcome. For example, while Fitbit usage was beneficial for patients with epilepsy in improving sleep quality, Fitbit devices were concurrently found unable to detect epileptic episodes (43). Consistently measured, though, was increased physical activity (MVPA and daily steps) after Fitbit use.

Because positive outcomes were achieved using Fitbit trackers with little to no negative consequences of wear, it is reasonable to state from this data that Fitbit devices are acceptable for recreational use and are potentially beneficial for improving generalized wellbeing and physical activity in children with chronic health conditions.

This determination is consistent with prior studies on adults. One study of Fitbit-based interventions in adults also measured increases in step counts, MVPA, and a decrease in weight, concluding that Fitbit devices had potential for promoting physical activity and weight maintenance (60). It has also been found that Fitbit use on purely recreational bases had no indication of being beneficial to those with chronic illnesses aside from acting as a motivator for physical activity (16).

Biases

An important notion to be cognizant of in a technological study such as this present review is the impact of device users' perceptions of the data outputted. Fitbit devices enable their wearers to retrieve and perceive their own data, which provides strong potential for misinterpretation, and/or invalid or non-objective data; individuals in the studies analyzed may have wrongly believed they were in good health or improving, or vice versa, and this may have affected how they perceived or behaved in clinical settings. This feedback visualization thus plays a role in our assessment of Fitbit experiences (feasibility, acceptability, advantages, and disadvantages) and clinical effects.

For the population studied in this review, children with chronic conditions, the accuracy of Fitbit devices is more questionable than for those without such health considerations. Some chronic health conditions, such as asthma, sleep apnea, and cystic fibrosis, affect the ability to carry out daily functions. However, Fitbit devices do not incorporate such factors into estimates of biometric information. Rather, these products base estimates on predetermined physiological data from (likely) able-bodied individuals and their respective heights, weights, sexes, and ages. Additionally, studies of Fitbit reliability more often assess Fitbit devices in terms of "free-living" conditions, "normal" walking, and other terms representing able-bodied people (26). This limits research of Fitbit accuracy for those whose conditions affect daily activities such as walking because less baseline and/or comparative data is available. Thus, a bias is likely present, resulting in inaccurate values produced by Fitbit trackers and an incomplete body of research on Fitbits for those with chronic illnesses.

Another bias is that these devices do not have child-specific data collection mechanisms (61). No study to date has directly compared accuracy of Fitbit devices between adults and children, however one thesis from the University of Delaware analyzed Fitbit accuracy in both populations of adults and children (62). The study concluded that the Fitbit Zip was acceptable for both children and adults in measuring sedentary and physical activity as well as step counts. Yet, as a relatively early study on Fitbit devices, its conclusions may not be as well-supported as recent papers. It has also been found that children walk faster than adults, accumulate more steps than adults, and have different cadences and frequencies of movements (63).

These findings inform our data analysis, given that our review includes study participants in all stages of young life; it is presumable that the data collected by younger participants would be less accurate than that collected by those older. Additionally, having a large age range may give way to greater deviations in data, whereas data in a narrower range (such as ages 0–18 or solely preschool and school age) might present more uniformly. It would be extremely difficult to assess the relative strengths of studies' datasets; moreover, that is beyond the scope of this paper. Rather, it is important to simply acknowledge age as a bias in our analysis.

Considering these factors—the disagreement among papers within this review, the lack of clarity on Fitbit products' mechanisms of biometric measurements, and the biases in Fitbit devices against those being studied in this review—Fitbit trackers are not reliably accurate devices for collecting physiological data in pediatric populations with chronic health conditions.

Strengths and limitations

There are several strengths of our study. Primarily, this is a seminal review within the field of research of children with chronic conditions, as such a multi-faceted approach (assessing health outcomes and intervention feasibility and accuracy) has yet to be considered. This is also true within the field of Fitbit research, as studies often either have assessed accuracy or effects on health outcomes, but rarely the combination of the two. Moreover, this is a preliminary study of Fitbit accuracy and outcomes specifically in pediatric populations. Another strength of this review is in it being a scoping review. Following the framework of a scoping, rather than a systematic, review enabled our study to analyze a broader range of articles with a variety of study designs. This was particularly beneficial in our study given that the intent of our paper was to assess the range of studies available on Fitbits in children with chronic conditions and evaluate evidence given the information collected. Lastly, a strength of our study is versatility of data and conclusions. The information collected from the articles studied may be utilized by medical professionals, meta-researchers, patients and families, Fitbit® and wearable technology companies, and more. By enabling a broad audience to utilize our review, this paper can inform future research in many fields as well as benefit those knowledgeable about/suffering from chronic health conditions.

The most significant limitation of our study is subjectiveness of the characteristics of Fitbit use we sought to assess. This is particularly true for feasibility and accuracy, where there were no universal nor defined thresholds for these parameters. It is unclear if Fitbit use being feasible means that participants consistently wore it or that they simply did not negatively comment upon it. Additionally, it is possible that the data presented on feasibility does not wholly represent all children studied; if some researchers did not ask participants to characterize their experience of Fitbit use, feasibility could not be assessed. The same could be true for accuracy: if Fitbit data was not compared against another measure, it is not possible to have assessed accuracy. Accuracy is also not universally defined, nor is an acceptable amount of error. This limits the accuracy of our conclusions because of discrepancies between studies; if one study stated that their data was overall inaccurate because only 80% of data was accurate, but another study decided that their 60% accuracy was relatively accurate, there would be a discrepancy in accuracy and the comparison of the data as inaccurate versus accurate would be poorly informed. Finally, it is worth noting that few of the studies included a mixed sample of adolescents and young adult patients who were younger or older than 24 years old, which is important to consider while interpreting the findings in our review.

Suggestions for future research

There is a paucity of research on Fitbit utilization by children with chronic health conditions, thus this preliminary study in this field serves to pioneer further related research. To our knowledge, no research has been conducted on the use of the Fitbit Ace [the brand's child-geared (ages 8+) device] and its effectiveness/accuracy. Learning more about this device could be instrumental in implementing stronger technologies, practices, and interventions to improve the health of pediatric populations with chronic conditions. Additionally, studies could research the effectiveness of Fitbit-based interventions in comparison to medically accepted devices and health promotion programs to determine if the effects of Fitbit use are comparable; perhaps even if Fitbit devices are not as accurate, there may be unidentified benefits that can be achieved from Fitbit usage. Similarly, another path for future research could be to assess if the potential health benefits of Fitbit devices outweigh the potential inaccuracies of such devices. This would align with the clinical findings of our study; since Fitbit devices have been shown to be strong activity motivators for users as well as beneficial in increasing physical activity, it would be of interest to understand what other clinical benefits of Fitbit products may exist and if these would persuade clinicians to suggest Fitbit devices to patients.

Conclusions

Fitbit devices have the potential for producing positive clinical outcomes in children with chronic health conditions, more so in terms of generalized physical health but possibly for disease-specific outcomes as well. Fitbit trackers have also been demonstrated to be a feasible tool for collection of biometric data, as reported by both children and their parents. Nonetheless, the data collected from the studies evaluated and additionally available literature cannot support reliable accuracy of Fitbit devices, especially in clinical settings. Our recommendation is that Fitbit use among children with chronic health conditions is viable for recreational use and in attempts to improve physical health (either alone or in conjunction with a program or intervention). If one needs and has access to medically accepted technology for biometric data collection, Fitbit devices should not be used in place of such tools. However, if access to medical facilities and equipment is limited, and the reason for utilizing Fitbit devices is not a critical nor severe health concern, Fitbit devices are a reasonable means of measuring one's own physical health on a basic level.

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Footnote

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