Review Article

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Promoting child and adolescent health through wearable technology: A systematic review

Wei Zhang[1], Keying Xiong[1], Chengyan Zhu[2], Richard Evans[3], Lijuan Zhou[4] and Christine Podrini[5]

Abstract

Background: Wearable technology is used in healthcare to monitor the health of individuals. This study presents an updated systematic literature review of the use of wearable technology in promoting child and adolescent health, accompanied by recommendations for future research.

Methods: This review focuses on studies involving children and adolescents aged between 2 and 18 years, regardless of their health condition or disabilities. Studies that were published from 2016 to 2024, and which met the inclusion criteria, were extracted from four academic databases (i.e. PubMed, Cochrane, Embase, and Web of Science) using the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) protocol. Data on intervention purposes, interventions deployed, intervention duration, measurements, and the main outcomes of the studies were collected.

Results: A total of 53 studies involving 14,852 participants were reviewed. They focused on various aspects, including the ownership and use of wearable devices ($n = 3$), the feasibility ($n = 22$), effectiveness ($n = 4$), and adherence ($n = 2$) of intervention strategies, or a combination of multiple aspects ($n = 22$). Among the interventions deployed, Fitbit was the most frequently used, featuring in 26 studies, followed by ActiGraph ($n = 11$). In intervention studies, the majority of studies focused on pre-morbidity prevention ($n = 26$) and the treatment of illnesses ($n = 20$), with limited attention given to postoperative monitoring ($n = 4$).

Conclusions: The use of wearable technology by children and adolescents has proven to be both feasible and effective for health promotion. This systematic review summarizes existing research by exploring the use of wearable technology in promoting health across diverse youth populations, including healthy and unhealthy individuals. It examines health promotion at various stages of the disease continuum, including pre-disease prevention, in-disease treatment, and postoperative monitoring. Additionally, the review provides directions for future research.

Keywords

wearable technology, children and adolescents, health promotion, systematic review

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Introduction

Wearable technology (or wearables), such as activity trackers and smartwatches, uses built-in sensors to collect personal health data from users. This data can be shared with health providers, enabling the delivery of remote healthcare services. Activity trackers (e.g. Fitbit) are engineered to capture real-time data on individuals' movements and biometrics through their integrated accelerometer, altimeter, and other sensors. They provide feedback through dashboards, smart phones, or other integrated applications enabling users to monitor their fitness and health conditions.[1]

[1]School of Medicine and Health Management, Huazhong University of Science and Technology, Wuhan, China
[2]School of Political Science and Public Administration, Wuhan University, Wuhan, China
[3]College of Digital Transformation, Faculty of Computer Science, Dalhousie University, Halifax, Canada
[4]School of Public Administration and Law, Hunan Agricultural University, Changsha, China
[5]The Bio Arte Limited, San Gwann, SGN, Malta

Corresponding author:
Chengyan Zhu, School of Political Science and Public Administration, Wuhan University, Wuhan, China.
Email: zhuchengyan0323@163.com

Wearable technology has the capability to capture a range of health data, including measurements such as heart rate, step count, and levels of moderate-to-vigorous physical activity (MVPA). Additionally, many wearables offer added functionality based on the needs of users.

Given the severe consequences associated with sedentary lifestyles, governments and health providers are increasingly promoting self-health management.[2,3] Wearables are playing an integral role in the detection, prevention, and control of chronic diseases, providing timely and accurate data compared with manual calculations.[4] Besides, wearables can collect a large amount of health data, facilitating data-driven treatments and real-time monitoring of individuals' physical metrics along with tailored treatment plans. Consequently, patients can remain in the comfort of their homes while doctors conduct remote monitoring, enabling the prompt identification of postoperative complications and necessary health interventions. As individuals' preferences toward physical activity tend to remain the same from adolescence to adulthood,[5] it is posited that wearable technology can play a beneficial role in health intervention and the promotion of healthier lifestyles, especially for children and adolescents.[6]

While current research has extensively investigated the use, functionality, and health implications of wearable technology,[7,8] examining aspects such as consumer compliance, accuracy of healthcare data collected, and the overall effectiveness of interventions deployed,[9–14] most have concentrated their efforts on elderly patients and adults. Although some extant studies examine the use of wearables by children or adolescents with chronic diseases, such as attention deficit hyperactivity disorder (ADHD)[15] and depression,[16] there is a scarcity of research that focuses on children and adolescents.[17] Consequently, this study presents a systematic literature review on the use of wearable technology by children and adolescents across the different stages of health promotion, including disease prevention, treatment, and rehabilitation. This study contributes to the current understanding about the use and health consequences of wearables in youth and offers future research directions for wearable technology-based intervention deployment in youth health promotion.

Methods

Search strategy

This systematic literature review followed the PRISMA protocol[18] to examine studies published from 1 January 2016 to 1 January 2024 since the industry of smart wearables in health promotion is expected to grow significantly after 2016.[19] The PRISMA checklist is presented in Appendix A. Four academic databases (i.e. PubMed, Cochrane, Embase, and Web of Science) were searched using the search terms presented in Appendix B, which were constructed using the PIO strategy, including population (e.g. child and adolescent), intervention (e.g. wearable electronic device and fitness tracker), and outcome (e.g. physical fitness, exercise, and physical activity). References of highly cited papers and previously published reviews were also traced to identify additional studies. The study was registered with the International Prospective Register of Systematic Reviews (PROSPERO) under registration number: CRD42024497488.

Eligibility criteria

Studies were considered eligible for inclusion if they met the following criteria: (a) written in English language; (b) featured children and/or adolescents aged between 2 and 18 years as the primary focus, irrespective of their health condition or disabilities; (c) reported at least one wearable technology as a component of the health intervention; (d) incorporated health promotion (e.g. exercise, sleep, or diet) as the main outcome; and (e) fell under one of the study types of feasibility study, intervention study, pilot study, or process evaluation study. Studies were excluded from consideration if they met the following criteria: (a) being book chapters, conference reports, or editorials; (b) used non-wearable health data collection methods to assess the health intervention; and (c) cases where the wearable technology was not the primary method of intervention. Two graduate students, studying health informatics, participated in the screening process. Any discrepancies identified during the review of literature titles, abstracts, and full texts were resolved through discussions with the first author.

Data extraction

The data extracted from all studies included author name, year of publication, study design, research setting, sample size, and participant characteristics (e.g. age and health condition). Details on intervention methods, duration, measurements, and the main outcomes of the studies were also collected. Additionally, the purpose of health promotion, such as disease prevention, treatment intervention, and postoperative rehabilitation monitoring, was captured. All extracted data were systematically recorded in Excel for subsequent analysis (see Appendix C for details).

Results

Study selection

Initially, 582 studies were identified, with an additional four discovered through reference checks. After removal of duplicates, 538 studies remained. Subsequently, 444 were excluded for not meeting the study's inclusion criteria, resulting in 94 studies considered for full-text review. In total, 53 studies met the criteria and were included in the final review. Please see Figure 1 for further details.

Characteristics of the included studies

Distribution of research. Most studies were published in 2020 ($n = 11$), 2017 ($n = 11$), 2021 ($n = 10$), and 2022 ($n = 7$) and mainly included the United States of America ($n = 19$), Australia ($n = 11$), and the United Kingdom ($n = 6$), as the research setting.

Nature of research. In total, 50 studies examined the feasibility, effectiveness, and adherence aspects of wearable technology. Of these, 22 studies reported on feasibility only, with four concentrating solely on effectiveness and an additional two on adherence. The remaining 22 studies addressed two or more aspects. Lastly, three studies investigated the popularity of wearables and its correlation with health promotion.[20–22] Appendix C presents the main results of each study.

The feasibility studies reviewed mainly examined the impact of wearable technology-based programs on health indicators with their focus being on assessing whether technological intervention led to any discernible changes in health outcomes. Some examples included the school-based *RAW-PA*[23–26] program, the home-based *Step-it-Up*[27] program, and the *B.E.S.T.R.O.N.G.*[28] program. Other studies examined the monitoring accuracy of one or more wearables across various activities, such as walking. The goal of these studies was to identify a reliable reference for selecting wearable technology tailored to specific purposes. For example, Physilog®5[29,30] and G-Walk[31] were considered reliable in gait data monitoring, while Meizu Bong 2s[32] and Garmin Vivofit Jr 2[33] were found to have good accuracy in counting users' steps. Fitbit Ace 2[33] and Fitbit Ace[34] were found to have less than ideal accuracy. The majority of studies demonstrated the feasibility of wearable

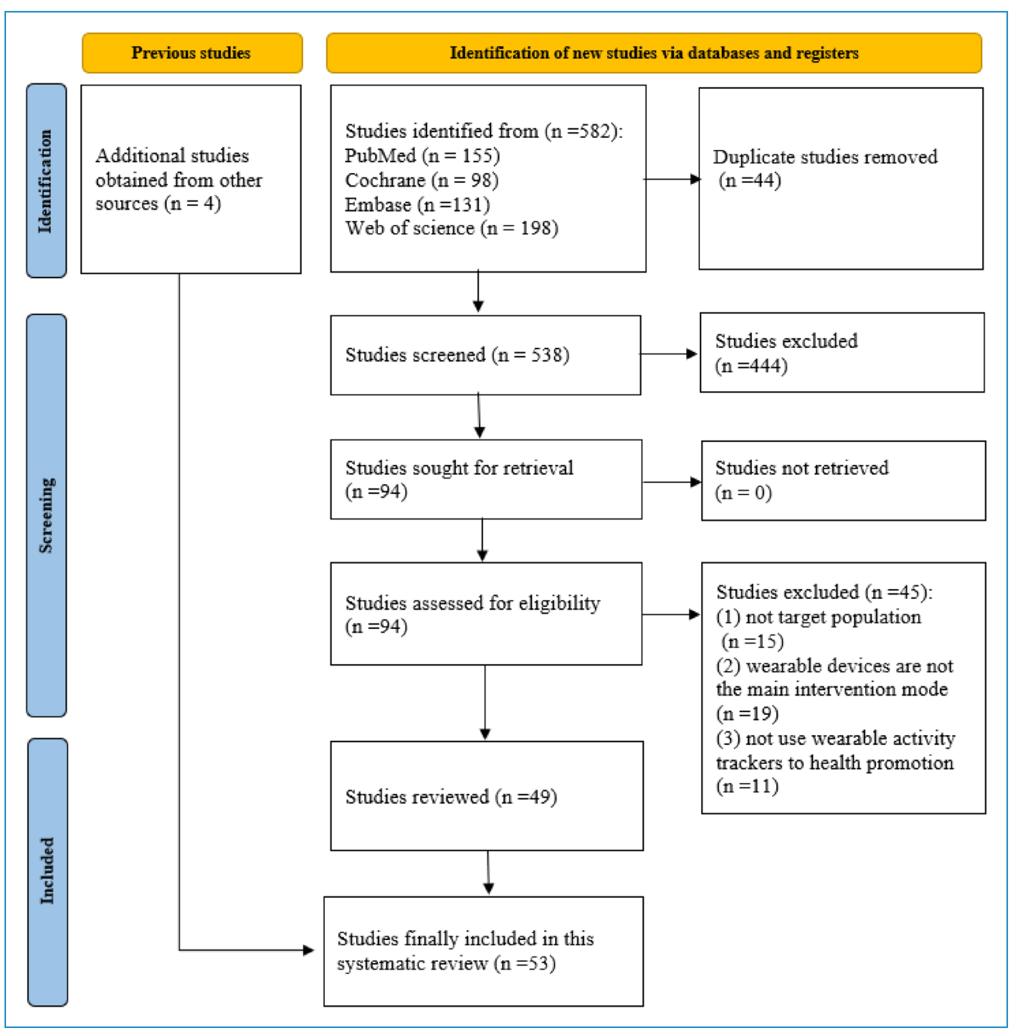

Figure 1. Flowchart of the study selection process.

technology interventions, while two studies obtained opposite conclusions[34,35] and four reported mixed results.[32,33,36,37]

In terms of effectiveness studies, most focused on assessing whether wearable technology interventions successfully achieved the intended outcomes for users, such as step counting or monitoring improvements in physical activity (PA). Under different interventions, 12 studies found that wearables are effective in achieving health goals, while other studies found that wearables did not promote PA.[23,38–42] The adherence studies reviewed focused on evaluating the practical use of one or more wearable devices, including considerations such as frequency, duration, and user willingness to wear the wearable. In total, 13 studies reported satisfactory adherence, while lower adherence was observed for wearables intended to be worn around the waist of users,[40] and adherence tended to decline in the later stages of the wearer's life.[43]

Research methodologies. With regard to the methodologies used in the reviewed intervention studies, 16 employed controlled experiments, while the rest collected data only before and after technology intervention without including a control group. This systematic literature review comprised 39 quantitative studies, 3 qualitative studies, and 11 studies that employed a mixed-methods approach.

For quantitative studies, data were captured using two methods. The first involved collecting data directly from the wearable technology, including metrics such as MVPA values, body mass index (BMI) values, step count, and wear time. The second adopted questionnaire surveys, for example the 3-Day Physical Activity Recall (3DPAR)[39] and the Patient-Reported Outcomes Measurement Information System (PROMIS®).[39,44] The latter method mainly focused on assessing self-reported physical activity, overall health, and the mental health status of users. A qualitative study was used to examine the feasibility of a school-based wearable technology. Through focus group discussions and interviews, the authors found that wearables can be used to motivate teenagers,[24] including those on the edge of race and economy[45] and those with autism.[46]

In studies employing a mixed-methods approach, researchers integrated data from wearables, questionnaires, and semi-structured interviews, to examine specific aspects of the wearable technology. For example, one study employed both questionnaires and focus group interviews and found that, despite the interview results indicating users' negative sentiment toward non-personalized goals, quantitative data demonstrated an increase in exercise motivation by 0.35, following the intervention, with controlled motivation showing a lesser rise of 0.04. These findings support the feasibility of wearable technology in increasing the physical activity of users.[47]

Theories and models. Of the reviewed studies, 10 used theories or models as intervention frameworks to guide the research. These included the Technology Acceptance Model,[24] Theory of Unpleasant Symptoms,[44] Motor Learning Theory,[48] Behavioral Choice Theory,[25] Self-Determination Theory,[27,47,49] Social Cognitive Theory,[25,27,49] Social Ecological Model,[50] "Capability, Opportunity, Motivation, and Behavior" (COM-B) model,[20] the Theoretical Domain Framework (TDF),[20] and Health Belief Model.[50]

Interventions deployed

Sample sizes and characteristics. This review targeted on children and adolescents, with a combined sample size of 14,852 and a wide variation in sample size, ranging from 2 to 8108 participants. Specifically, 45.3% (24/53) of the studies included 25 to 100 participants, 28.3% (15/53) had more than 100 participants, and 26.4% (14/53) had fewer than 25 participants. Many studies limited participant demographics by age and health status, with some adding additional criteria, such as limiting prior experiences in using wearables to ensure accurate data capture.[27,39,46,51–53] The majority of participants were aged between 6 and 12 years old and 13 and 18 years old with one study focused on preschool-aged children (2–5 years).[54] Although the majority of interventions focused on healthy children and adolescents, 20 examined children with chronic diseases, such as asthma,[55,56] obesity,[28,34,42,57] cerebral palsy (CP),[31,48,58] ADHD,[53] and cancer.[51] Additionally, four focused on postoperative children.[44,59–61]

Duration of interventions. With regard to the duration of interventions, the majority of studies ($n = 21$) lasted from 4 to 10 weeks. Specifically, the longest intervention lasted 18 months,[62] conducted as part of a UK-based study that monitored the adherence of 886 students with wearable technology. In contrast, the shortest study lasted 12 minutes.[36]

Intervention indicators. Studies focused on the prevention of diseases typically collected exercise-related data (e.g. steps, heart rate, and MVPA time) over time using wearables. In contrast, studies centered on disease treatment and post-operative monitoring collected a broader range of data related to users' diets (e.g. intake of fruits, vegetables, and dairy products),[28,63] sleep (e.g. waking time),[4,46,56,57] emotional state,[53] screen use,[28] and gait (e.g. stride time, stride length, and velocity).[29–31,48]

Wearable technology. In the 53 studies, three studies on the ownership rate of wearable devices did not specify the specific devices used.[20–22] Out of the remaining 50 studies, 35 focused on a single wearable technology, while 15 explored the use of two or more wearables. For further analysis, wearables were classified into two categories based on data accuracy:

consumer-grade and research-grade. Consumer-grade wearables provide moderately accurate data suitable for general use, addressing self-management needs in both healthy populations and individuals with chronic diseases at an affordable price. In contrast, research-grade devices are mainly used to determine baseline PA measurements and to provide specialized recovery training, ensuring high accuracy. For example, they are often used to improve the walking ability of patients with CP.

The most frequently used consumer-grade wearables were from the Fitbit product range ($n = 26$), including the Fitbit flex ($n = 12$),[4,23–26,32,35,49–51,53,54] Fitbit charge HR ($n = 3$),[38,64,65] Fitbit zip ($n = 2$),[40,45] Fitbit inspire ($n = 2$),[46,61] Fitbit Alta HR ($n = 2$),[34,66] Fitbit charge ($n = 1$),[40] Fitbit Ace 1 ($n = 1$),[36] and the Fitbit Ace 2 ($n = 1$).[33] Two studies did not specify the Fitbit product used.[42,47] All devices were worn on the wrist of users, except for two studies that adopted the Fitbit zip, where users wore the wearable around their waist.[40,45] Additionally, 11 studies used ActiGraph research-grade wearables, including the ActiGraph GT3X ($n = 6$),[23,25,32,38,50,64] ActiGraph WGT3X-BT ($n = 4$),[33,37,56,59] and ActiGraph GT9X ($n = 1$),[64] which were worn around the wrist or hips of users.

The GENEActiv wearable, categorized as research-grade, was mainly used to determine the baseline PA of users and was used in four of the reviewed studies.[6,62,67,68] Wearables were mainly attached to users' wrists, shoes, or clothing dependent on the type of activity being completed. In addition, two studies used customized wearables that were worn on the waist and ankle of users,[48,58] while a number of alternative wearables were noted, including the Apple Watch,[44] kidfit,[52] and Fitsight.[69] Appendix D provides further details on the wearables used in the reviewed studies.

Intervention measures. To improve the impact of digital health interventions, some studies attempted to create a more comprehensive digital ecosystem by combining various modes, such as smart wearables, mobile applications, and short message services (SMS).[4] Among the studies reviewed, 34% (18/53) incorporated mobile applications as part of the intervention, mainly to support the use of the wearable, such as to receive notifications. Additionally, 9% of studies (5/53) added an SMS feature to motivate and remind users to achieve their goals. Eleven percent of studies (6/53) included social media integration as part of the intervention to increase participation. In addition, 14 studies incorporated gamification mechanisms (e.g. reward systems) to create competition between individuals and groups to increase participation, thus strengthening the intervention.

Applications of wearable technology

Ownership and use of wearable devices. Of the studies reviewed, three studies investigated the ownership and use of wearable devices.[20–22] In one study, a national survey was conducted with 831 children and adolescents and revealed that most (51.6%) had never used wearable technology, while 252 (30.3%) were current users, and 150 (18.1%) had used wearables in the past.[19,20] Another study, conducted with 755 teenagers from the Czech Republic, highlighted a significant adoption of physical activity trackers (PATs).[22] This finding supports the results of a survey conducted in Finland, which included 8108 teenagers and demonstrated a substantial ownership and usage of PATs. The authors of the latter study concluded that the adoption of wearables was higher among teenagers who used mobile applications for measuring activities.[70]

Wearables for preventive healthcare. Among the studies focused on preventive healthcare ($n = 26$), the main goal of the intervention was to reduce the risk of chronic diseases in children, including obesity and vision loss resulting from inadequate physical activity, and to identify feasible and effective measures to increase children's MVPA, ultimately reducing their sedentary lifestyles.

Based on the results of technology intervention, 18 studies identified that wearable technology can increase MVPA time and improve the physical activity of children and adolescents. Feedback obtained from participants showed that stylish and comfortable wearables increased users' willingness to wear them for extended periods.[40,50,62] Similarly, user-friendly interfaces motivated participants to achieve their daily exercise goals.[27] Additionally, some participants were more willing to engage in activities when the intervention included gamification mechanisms, such as competitions.[24,49] Four studies reported that wearable technology did not correlate with MPVA time or overall PA levels.[23,38,40,41] Furthermore, studies examined user adherence to interventions using various methods, for example interviews and questionnaires.[38] One study investigated the relationship between adherence to wearable technology and cold weather.[41] Meanwhile, the position of the wearable was sometimes found to be inconvenient, and the battery life affected users' experience.[40] For example, in Canada, researchers found that the lack of waterproofing of wearables led to a significant reduction in adherence.[38] In addition, studies also found that compliance was affected by novelty effect, resulting in observable changes in PA level in short-term studies.[24,47] Conversely, long-term studies led to participants losing interest in the technology and no longer wearing it, as required. The remaining studies reported the feasibility and validity of 18 wearables on different measures of physical activity indicators, presenting mixed results.[32,33,36,37]

Wearables for controlling auxiliary disease. Given that patients with chronic diseases typically exhibit lower levels of PA compared to healthy children, a situation that may limit rehabilitation efforts, it is critical that a well-designed exercise plan is included as part of the intervention.[17] Of the studies reviewed, 20 focused on monitoring patients with chronic diseases. Fifteen of these studies reported positive results and five studies were negative results.

Specifically, wearable device-based interventions have been regarded as feasible and effective in the rehabilitation of individuals with spina bifida[17] and CP.[31,48,58] Through the use of a professional-grade customized ankle exoskeleton wearable device, it is possible to effectively improve the performance of people with cerebral palsy in relation to physical activity.[48,58] It has also demonstrated feasibility in patients with disabilities[65] and asthma[55,56] with good adherence. The study found that the monitoring of physiological parameters was related to asthma control evaluated by pediatricians, demonstrating the potential of commercial-grade wearables to monitor asthma.[56] In addition, it was found to be feasible in patients with ADHD,[53] autism spectrum disorder,[46] congenital heart disease,[64] Prader–Willi syndrome, and Angelman syndrome.[30] The investigation conducted in patients with cystic fibrosis pulmonary disease showed good adherence.[66]

The results regarding wearables in patients with cancer, obesity, and arthritis are mixed. Two studies involving obese children found that wearable device interventions were feasible and effective in increasing physical activity,[28,57] while two other studies concluded that wearable devices did not promote physical activity.[34,42] Two studies involving cancer patients reported high adherence, but did not reach a consensus on feasibility outcomes.[35,51] Additionally, two studies involving juvenile idiopathic arthritis patients demonstrated the feasibility of wearable device interventions, but reported conflicting results on adherence.[39,43]

Wearables for postoperative recovery monitoring. In total, four studies focused on the use of wearable technology to monitor postoperative recovery. These comprised two feasibility studies,[44,61] one pilot study,[59] and one compliance study,[60] which focused on patients with selective tonsillectomy.

A study involving surgical patients utilized wearable devices to estimate surgical recovery time through 21 days of postoperative monitoring. The study identified differences in exercise levels between general inpatients and outpatients.[59] Based on these findings, it was concluded that wearable devices could serve as a valuable adjunct to traditional methods of assessing recovery after pediatric surgery and aid in the early identification of postoperative complications. Another study focused on tonsillectomy patients and found that data obtained from wearable devices was more accurate compared to parent-reported logs and step counts.[60] This finding further supports the use of wearable devices as part of an assessment of children's overall well-being during or after an intervention. In the postoperative monitoring of appendectomy patients, it was found that measurements of heart rate and step counts from wearable devices were able to present a postoperative recovery trajectory.[61] Furthermore, another study advanced the visualization of postoperative recovery trajectories in postoperative children undergoing blood and bone marrow transplants.[44] The study noted that data collected by wearable devices can be used to help patients, caregivers, and clinicians monitor symptoms and develop personalized health strategies.

Discussion

Following the PRISMA protocol, this systematic literature review examined studies published from 1 January 2016 to 1 January 2024 on the use of wearable technology in promoting child and adolescent health. Initially, the review focused on the fundamental characteristics, methods, and theories and/or models used across the 53 reviewed studies. Then, the review examined the intervention targets, cycles, wearables deployed, and supporting measures used. Finally, using real-world research contexts of wearable technology, the studies were categorized into application surveys, preventive healthcare investigations, disease surveillance studies, and postoperative detection studies for generalization.

Characteristics of studies

First, most studies included in this review were conducted in developed countries, such as the USA and the United Kingdom, while only a few investigated the use of wearable technology among children and adolescents in developing countries. These countries are limited by their level of economic and cultural development, and there may be room for improvements in the popularity, use, and design of supporting programs for wearables. Future research should, therefore, prioritize investigating and enhancing the use of wearable technology specifically in developing countries.

Second, in terms of the nature of the studies, most examined and demonstrated the feasibility and effectiveness of wearables in health promotion, which is consistent with the findings of previous studies.[71–73] A limited number of studies focused on the adherence of users, obtaining acceptable results. Studies found that for various age groups, wearables and intervention programs may lead to differences in adherence levels, which can have implications for the feasibility and effectiveness of health promotion. Nevertheless, there exists a research gap in examining adherence with various wearables, presenting itself as a promising avenue for future research.

Finally, with regard to research methodologies and theoretical frameworks, the review found that most studies lacked a control group, and some had relatively small sample sizes, introducing certain limitations. Future research can enhance their design by addressing these limitations and adopting a more robust approach. Incorporating relevant theories and employing a combination of qualitative and quantitative methods would further contribute to developing a comprehensive understanding.

Interventions deployed

First, this review identified a scarcity of studies examining the 2–5 age group, potentially linked to the generally good health status of this demographic. The reduced emphasis on increasing PA or reducing sedentary behaviors in this age range may contribute to the limited research available. Although some studies collected data across a broad age range, there is a notable absence of simultaneous analyses comparing the effects of applications in different age groups. Therefore, future studies should examine findings specific to different age groups. Furthermore, the review highlighted a balanced representation of studies for both healthy and non-healthy populations which demonstrates the significance of wearables not only in preventive healthcare but also in showcasing their potential for improving disease management.

Second, the design of wearables can be improved. Human factors, such as the placement of the wearable technology on the human body, waterproof capability, battery life, appearance, real-time feedback functionality, goal-setting features, and data transmission methods, significantly influence intervention outcomes. This review found that wearables worn on the wrists generally showed better adherence during daily activities compared to other positions. However, data accuracy varied, with most being less accurate than research-grade devices worn on the waist. Existing reviews provide important insights into the reliability, accuracy, and acceptability of wristband wearables[11,74,75]; however, there is a need for studies that specifically address the accuracy of activities among adolescents and children. Furthermore, many wearables deployed in the reviewed studies were not customized to the requirements of children and adolescents, potentially lacking relevance and appeal. Future studies should use more age-appropriate wearables tailored to different age groups and practical applications, such as the Garmin Vivofit Jr, designed for children over 4 years old, or the Fitbit Ace 2, which was created for children over 6 years old.

Finally, diverse packages of wearable device interventions should be available. In terms of supporting measures, current wearables are often customized to various age groups. Interventions using wearables for preschoolers strategically emphasize their cognitive abilities and interests, using accessible modalities (e.g. interacting with a virtual dog) to attain predefined activity goals and effectively elevate their PA levels. Motivational strategies for children and adolescents, such as SMS text messages, phone calls, and individual or group competitions (gamified experience), are frequently employed. These measures consider age-specific characteristics and abilities, ensuring better alignment. Furthermore, many of the intervention programs that use wearable technology are focused on either school- or home-based participants. Involving others in these programs, particularly parents in home-based settings, can boost the motivation of children and adolescents to participate. It is recommended in future studies, therefore, that parents use wearables alongside their children to enhance the intervention's effectiveness. For adolescents, who mainly engage in PA at school, wearables are found to be effective in promoting PA when integrated with gamification mechanisms (e.g. class competitions and weekly challenges). Future research should examine the distinct effects of different intervention types.

Application of wearable devices

At present, there is a scarcity of research that examines the prevalence of wearable technology among children and adolescents and the influencing factors involved. While numerous studies have recognized the potential of wearables in health promotion, the belief in these findings requires practical application. Therefore, in future studies, researchers should develop a deeper appreciation of the wearables used across various regions and draw comparisons. This approach will enable subsequent studies to create more customized intervention programs that align with the realities of diverse locations.

Studies that are focused on disease management typically use wearable technology to monitor the PA levels of children with chronic diseases or aid patients with mobility issues in regaining their movement. The aims of such studies are to examine whether wearable technology can effectively promote exercise among young people and to develop evidence-based exercise programs. In general, wearables have demonstrated feasibility and effectiveness in disease surveillance, as supported by a review addressing the prevention and treatment of obesity in children and adolescents that reached similar conclusions.[73] Additionally, reviews exploring the use of wearables in diagnosing cardiac arrhythmias and neurological disorders have been documented.[76,77] Although this review did not include studies focused on children and adolescents in these areas, it presents a potential avenue for future research. For children and adolescents with chronic diseases who can move freely, there is a need for more prolonged and continuous monitoring. Therefore, designers of wearable technology are encouraged to optimize the data monitoring capabilities of commercial-grade wearables. This optimization aims to create uniform data standards across homes, schools, and hospitals, fostering the creation of an ecological network of wearable technology.

In postoperative monitoring, wearable technology plays a critical role in illustrating the recovery trajectory by continuously monitoring various data points, including sleep, heart rate, step count, and the duration of activities. All the studies reviewed include valuable supplementary tools to traditional methods for monitoring postoperative recovery. This contribution aids in estimating postoperative recovery time, creating symptom management strategies, and identifying any postoperative complications at an earlier stage. Furthermore, the assessment of children and adolescents' PA, pain control, and QoL parameters, post-operation, is changing from subjective evaluations to objective measurements. However, it is important to recognize that the sample sizes of the reviewed studies were relatively small, possibly attributed to challenges in data acquisition. Future studies should, therefore, enhance the exploration of wearable technology in postoperative monitoring for children and adolescents by incorporating larger sample sizes, thus enriching the study's findings.

Conclusion

In general, wearable technology designed for children and adolescents demonstrates feasibility and has the potential to effectively contribute to health promotion. However, there is room for improvements in research regarding intervention program design, wearable selection, and practical applications. This systematic literature review extends previous efforts by examining the use of wearable technology in both healthy and unhealthy youth populations for health promotion across all stages of the disease spectrum. This includes pre-disease prevention, in-disease treatment, and postoperative monitoring, thereby offering important insights and future research directions.

However, like most reviews of this type, it is not without certain limitations. First, only 16 of the reviewed studies used a controlled experimental design, requiring caution in drawing conclusions. Future reviews could enhance the robustness of their findings by conducting thorough quality assessments. Second, the variation in measurement indicators used across the reviewed studies poses a challenge for unified comparisons. Future efforts in the field of wearable technology for youth health promotion are encouraged to employ more specific metrics and, if data allows, consider conducting meta-analyses for a more comprehensive understanding.

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Guarantor: Chengyan Zhu.

ORCID iDs: Wei Zhang https://orcid.org/0000-0003-0178-0750
Chengyan Zhu https://orcid.org/0000-0002-3879-9124

Patient consent: Since our study is a systematic review, it does not directly collect data from patients or participants. For the studies included in our review, we did not have direct access to patient/participant information or the ability to seek additional consent.

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