

Cutting-Edge Applications of Wearable Technology in Exercise Monitoring: A Brief Literature Review

Zhiming Liu, Yibo Meng, Sunan Tian, Bingyi Liu, Yiqi Xiao, Zhihao Lei, Zhefang Hu

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Abstract

Background: Over the past decade, wearable technology has garnered significant attention for its role in personal health management, particularly in activity monitoring and chronic disease management. These devices continuously collect physiological data, enabling users to track fitness and health metrics in real time.

Objective: This review aimed to synthesize the current literature on the applications of wearable technology in activity monitoring, chronic disease management, and rehabilitation, and to explore future research directions and technological advancements.

Methods: This review followed the PRISMA guidelines and conducted a systematic literature search across multiple databases, including PubMed, the Cochrane Library, IEEE Xplore, and Web of Science. Studies published between 2010 and 2025 were included, with a focus on wearable devices for health monitoring. Data extraction and quality assessment were performed using the Critical Appraisal Skills Programme (CASP) checklist.

Results: This review included 19 studies, focusing on the effectiveness of wearable devices in promoting physical activity, optimizing athletic performance, and supporting chronic disease management. Key findings include the potential of integrating multimodal sensors for real-time monitoring, AI-driven analytics for personalized health insights, and the role of wearable devices in rehabilitation. However, challenges remain, including data accuracy, user adherence, and privacy concerns.

Conclusions: Conclusion: Wearable technology demonstrates significant potential for enhancing health monitoring and exercise management. Future developments should address current limitations, including improving sensor accuracy, ensuring user comfort, and establishing standardized data protocols. With continued innovation, wearable devices are expected to become indispensable tools for proactive and personalized healthcare.

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Keywords: Wearable technology; Exercise monitoring; Physiological metrics; Systematic review

Introduction

In recent 10 years, there has been a growing public interest in personal health management. Wearable monitoring devices, known for their ability to continuously capture physiological data and manage fitness habits, have become preferred tools among health-conscious individuals. These devices are increasingly integrated into daily life and exercise contexts, assisting users in better understanding their physical performance and activity profiles. Recent evidence suggests that advancements in wearable systems have enhanced their capacity to monitor and analyze physical health, enabling more precise assessments (1). Studies such as (2,3) have demonstrated that wearable devices can capture bioelectrical signals induced by physical activity in real time, while others (4,5) have highlighted their potential in detecting activity-related biomarkers.

Beyond physical activity monitoring, photoplethysmography (PPG) and other optical sensors are commonly used for cardiovascular monitoring (6,7). Fitness bands and smartwatches typically rely on PPG to measure pulse waves, allowing users to track heart rate and rhythm in both clinical and everyday settings (8,9). However, challenges such as motion artifacts, signal noise, and variations in skin tone still affect the accuracy of the collected data (10).

By combining motion data with individual health indicators, wearable devices not only serve as tools for evaluating physical condition and generating personalized training plans but also act as motivators that support adherence and enhance well-being (11,12). The potential benefits of wearable technologies in health and performance monitoring are substantial, and continuous technological progress is expected to further improve their effectiveness. In addition to fitness tracking, wearable devices show considerable promise in healthcare, rehabilitation, and chronic disease management (13–15). These technologies support continuous monitoring of key physiological parameters such as heart rate, blood pressure, and body temperature, as well as comprehensive health indicators including electrocardiogram (ECG), ballistocardiogram (BCG), blood oxygen saturation, hydration levels, and sleep patterns (16–18).

By detecting these parameters, wearable devices enable rapid and accurate assessments of individual health status and hold significant value for personalized rehabilitation, medical diagnosis, and follow-up treatment strategies. Through long-term monitoring, wearables can detect early changes in health conditions and support timely interventions, thereby reducing disease risk and improving the efficiency of chronic disease management and prevention (19,20).

In summary, wearable devices have the potential to transform healthcare by enabling real-time, continuous monitoring of key health indicators, especially in early disease detection, timely intervention, and personalized care. With ongoing technological breakthroughs in sensor precision, mobile computing, and artificial intelligence integration, wearable technologies are evolving from basic data recording tools into intelligent health platforms—combining AI algorithms, physiological modeling, and remote healthcare services (21,22). These trends are driving the fields of activity monitoring, chronic disease management, and predictive healthcare toward greater precision, intelligence, and ecosystem-level integration.

Against this backdrop, the present review aims to forecast future research directions in wearable technology and identify promising application areas and technological improvements. To this end, we conducted a systematic analysis of literature published over the past decade, focusing on the applications of wearable devices in physical activity monitoring, chronic disease management, and rehabilitation. To ensure methodological rigor, we followed the PRISMA framework and employed the Critical Appraisal Skills Programme (CASP) checklist to guide our search strategy and literature screening. Drawing from multiple databases, we provide a comprehensive overview of current wearable health technologies, their development trajectories, and the key challenges that remain.

Ultimately, this review not only synthesizes the current landscape of wearable health monitoring technologies but also emphasizes existing knowledge gaps and future directions for exploration. Our findings offer theoretical insights to inform technological innovation and clinical translation, with the goal of improving healthcare quality and quality of life for patients with chronic conditions.

Method

Review Objectives

This study aims to investigate the benefits of using wearable technology, in conjunction with clinical research, for personal health monitoring. Through a comprehensive review of existing literature, we assess the potential of wearable devices to provide increasingly accurate monitoring of individual health status and to support future health forecasting. We grouped the applications of wearable technology into three categories: (1) the effects of wearables on physical activity, (2) the use of wearables for health and exercise monitoring, and (3) considerations for the future development of wearables. Our analysis focused on the impact of wearables on users' physical activity levels and the effectiveness of devices designed for health and activity monitoring. We also explored how wearable devices might enable early prediction and intervention for future health status based on a user's current physiological condition.

By exploring recent developments in this field, we also consider the future directions of wearable technology and its capacity to promote overall health and well-being. Ultimately, the findings of this review may help to improve the life expectancy and health outcomes of wearable device users.

Search Strategy

A comprehensive electronic literature search was conducted across multiple databases to identify relevant studies. To ensure full coverage, the search strategy was developed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (23). The goal was to retrieve a broad range of studies situated at the intersection of "wearable technology" and three core application domains: exercise monitoring, chronic disease management, and rehabilitation medicine.

In late 2024, we systematically searched several databases, including medical databases (PubMed, Cochrane Library), technology-oriented databases (IEEE Xplore, ACM Digital Library), and multidisciplinary databases (Web of Science, Google Scholar). The search terms focused on variations of keywords such as "wearable", "wearable devices", and "health monitoring", combined with domain-specific terms including "sports", "exercise", "chronic disease", and "rehabilitation". Boolean operators were applied to construct flexible and inclusive search strings that captured alternative phrasings and terminologies. The publication window was limited to studies published between 2010 and 2025, to reflect the evolution of wearable technologies over the past decade. All retrieved results were imported into reference management software for deduplication before proceeding to the next stages of screening and selection.

Table 1. Searching strategies in each database.

Strategy	Web of Science	Cochrane Library	PubMed/Medline
("Wearable design" OR "system*") AND ("activity monitor*" AND "physical	3645 (Reviews: 2966; Articles: 600; Others: 78)	3 (Trials: 3)	979 (Trials: 456; Reviews: 523)

exercise*") NOT "brain imaging" NOT "deep monitoring"				
("Smart wearable device" OR "chronic disease management") AND "medical rehabilitation"	5854 (Reviews: 1960; Articles: 3609; Others: 285*)	(Reviews: 647 (Trials: 631; Articles: 14; Others: 2*))	2372 (Trials: 1557; Reviews: 815)	
("Wearable equipment" OR "disease management") AND ("rehabilitation management") AND ("exercise management") NOT "neurological monitoring" NOT "stroke"	1358 (Trials: 1; Reviews: 1134; Articles: 10*; Others: 213)	1587 (Trials: 1558; Reviews: 29)	3419 (Trials: 1631; Reviews: 1791*)	
("Daily physiological monitoring" OR "rehabilitation management") AND ("medical rehabilitation") AND ("exercise training") NOT "neurological monitoring" NOT "stroke"	134 (Reviews: 113; Others: 21)	2036 (Trials: 2025; Reviews: 11)	157 (Trials: 76; Reviews: 81)	
Total	10991	4273	6927	

Inclusion and Exclusion Criteria

Clear inclusion and exclusion criteria were established here to guide the selection process.

Inclusion criteria were:

- (1) Relevance of content: Studies must focus on the application of wearable devices in health monitoring or intervention, specifically within one of the following three domains: exercise monitoring, chronic disease management, or rehabilitation medicine.
- (2) Type of publication: Eligible studies included randomized controlled trials (RCTs), cohort studies, and other empirical investigations, as well as relevant systematic reviews, meta-analyses, and high-quality design-based studies (e.g., development and evaluation of wearable systems).

Exclusion criteria were:

- (1) Studies on wearable technology that were unrelated to health monitoring (e.g., those focused solely on fashion design) were excluded.
- (2) Non-peer-reviewed literature lacking primary data, such as conference abstracts, book chapters, and opinion pieces, was not considered.
- (3) In cases of duplicate publication or substantially overlapping content, only the higher-quality or most recent version was retained.

Data charting process

Data were charted independently by two reviewers using a standardized data extraction form developed based on the study objectives. Extracted information included authors, year of publication, country, study design, population, type of intervention, outcomes assessed, and key findings. Any discrepancies between reviewers were resolved through discussion or by consulting a third reviewer. Data charting was managed using Microsoft Excel.

CASP Quality Assessment

All included studies were evaluated using the Critical Appraisal Skills Programmer (CASP) tools developed in the United Kingdom. The appropriate CASP checklist was selected based on each study's research design (e.g., RCT, cohort study, or qualitative study) to systematically assess various dimensions, including the clarity of research aims, methodological rigor, validity of results, and strength of conclusions. Based on the CASP scores, each study was classified into one of three categories: high quality, moderate quality, or low quality. The quality assessment results are summarized in Table 1, providing an overview of the methodological soundness of the included literature.

Overall, most studies fell within the moderate-to-high quality range. For example, several randomized controlled trials and systematic reviews met the majority of CASP criteria and were rated as high quality. In contrast, some studies on wearable prototype development were categorized as moderate quality due to limitations such as small sample sizes or the absence of long-term follow-up data. A minority of early exploratory studies exhibited methodological flaws and were rated as low quality. These quality assessments serve as a critical reference point for interpreting and weighing the strength of evidence in subsequent sections of the review.

PRISMA Flow Diagram

The literature selection process followed the PRISMA flow diagram, as illustrated in Figure 1. A total of 18,961 records were identified through database searches (PubMed, Cochrane, Web of Science, and Scopus). After removing 9,636 duplicates, 9,325 records remained for screening. During title screening, 8,677 records were excluded, and 648 abstracts were assessed. Following abstract screening, 205 more records were excluded. Of the 443 full-text articles assessed for eligibility, 426 were excluded due to being non-English ($n = 17$), having wrong question/design ($n = 371$), or lacking full text ($n = 19$). Ultimately, 19 studies were included in this review.

Figure 1. Presents a detailed breakdown of each stage of the screening process, along with the reasons for exclusion.

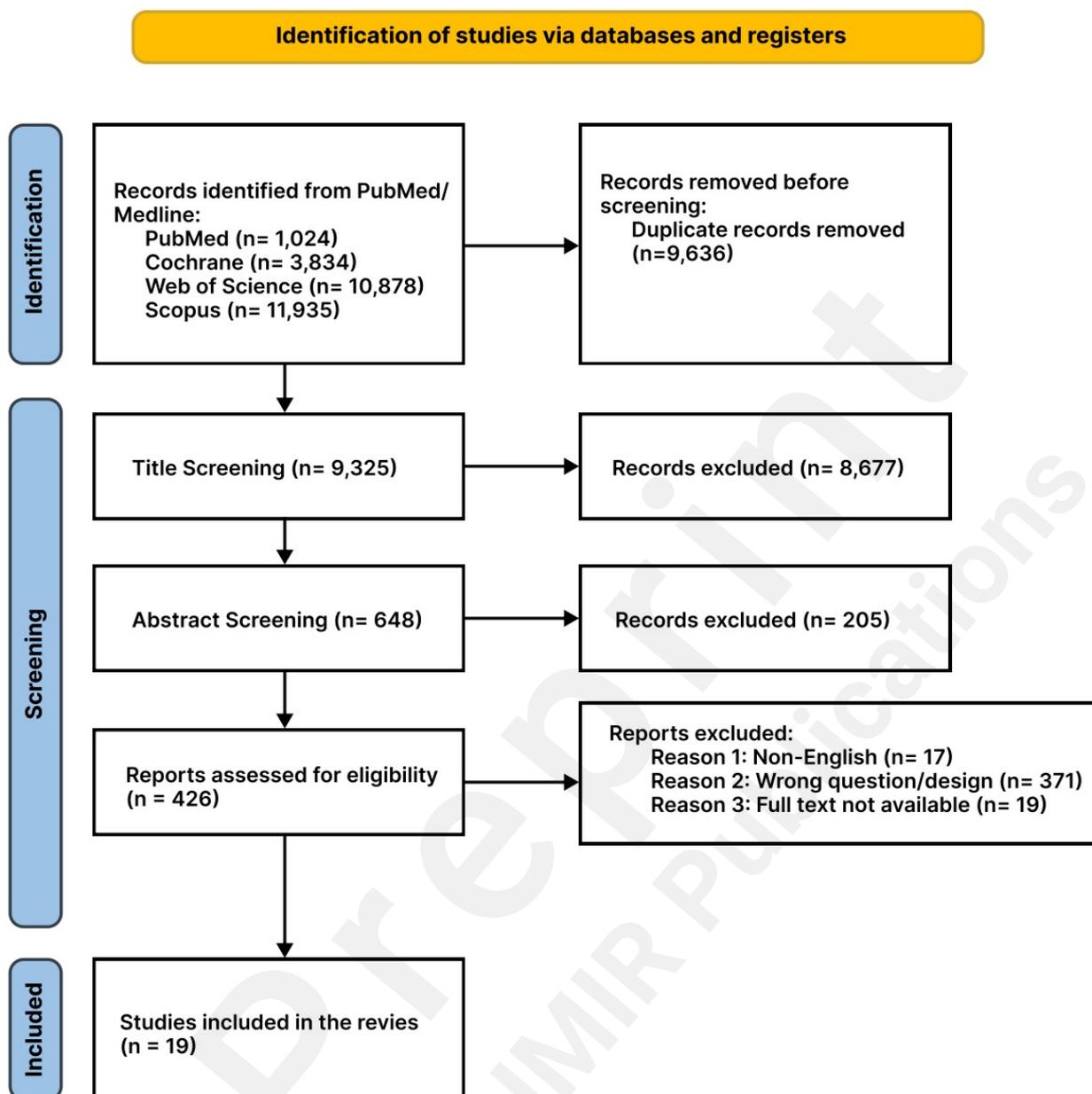


Table 2. Selected articles.

Year	Author	Title	Conclusion
2025	Soyoung Shin, et al. (24)	A bioinspired microfluidic wearable sensor for multiday sweat sampling, transport, and metabolic analysis	This study introduces BMS3, a bioinspired microfluidic wearable sweat sensor system capable of continuous, multi-day metabolic monitoring. Inspired by pitcher plant trichomes and lotus leaf structures, it integrates hierarchical microchannels and Janus membranes to achieve efficient, low-volume, and sustained sweat collection and renewal. Using a low-dosage carbachol gel module, it locally induces sweat secretion and maintains sample flow for up to 48 hours without

			repeated stimulation. The system's design ensures efficient sweat harvesting, transport, and waste removal, effectively overcoming the endurance and contamination challenges of conventional sweat sensors.
2025	Roberto M Benzo, et al.(25)	Comparing the Accuracy of Different Wearable Activity Monitors in Patients With Lung Cancer and Providing Initial Recommendations: Protocol for a Pilot Validation Study	This is the first study that validates WAM accuracy for populations with LC while providing comprehensive recommendations for future validation studies. This study will provide critical insights into the accuracy and reliability of WAMs for assessing PA in LC survivors, which are essential for interpreting clinical research and informing future interventions.
2025	Yue Sun, et al.(26)	Wearable Technologies for Health Promotion and Disease Prevention in Older Adults: Systematic Scoping Review and Evidence Map	Wearable devices hold great promise for promoting health in older adults, but several hurdles remain for full adoption. A broader and more diverse group of older adults is needed to identify the most beneficial wearables and to optimize the technology. Further studies are required to statistically synthesize real-world performance and evaluation results. We hope that this review will serve as a valuable reference for the development of wearable devices in older adults.
2024	Jessica R. Walter, et al.(27)	From lab to life: how wearable devices can improve health equity	Wearables offer a unique opportunity to redefine what biomarkers we measure, how we capture this information, where data is collected, and the final frontier of how we make this physiological data actionable. Wearables are a unique part of the digital health revolution because they rely on a physical connection to a patient but can remotely connect that person to a vast healthcare infrastructure.
2024	Ziao Xue , et al.(28)	Wearable mechanical and electrochemical sensors for real-time health monitoring	Wearable sensors can monitor multiple key physiological and chemical signals in real time, with wide applications in both commercial and medical fields. However, current devices lack sufficient flexibility, breathability, and comfort, limiting their use in extreme environments. Future development should focus on flexible, breathable materials and multi-environment adaptive designs to enhance accuracy, stability, and durability, while

			optimizing the correlation between clinical monitoring indicators and biomarkers.
2024	Whitney W Au, BBiomedSc, et al. (29)	Effect of wearable activity trackers on physical activity in children and adolescents: a systematic review and meta-analysis	Our findings demonstrate that wearable activity tracker interventions might increase daily step counts, but not moderate-to-vigorous physical activity, in healthy children and adolescents and those with suboptimal health, showing the potential of wearable trackers to motivate physical activity and improve health in young populations. Comprehensive tests confirmed the robustness of the null effect on moderate-to-vigorous physical activity, although more rigorously designed studies that minimise missing data are warranted to confirm the positive findings on steps and explore possible long-term effects.
2024	Ben Singh, et al.(30)	Real-World Accuracy of Wearable Activity Trackers for Detecting Medical Conditions: Systematic Review and Meta-Analysis	Wearable activity trackers show promise in disease detection, with notable accuracy in identifying atrial fibrillation and COVID-19. While these findings are encouraging, further research and improvements are required to enhance their diagnostic precision and applicability.
2023	Balasundaram Kadirvelu, et al.(31)	A wearable motion capture suit and machine learning predict disease progression in Friedreich's ataxia	Existing digital biomarkers applied in human clinical settings involve supplanting conventional measures such as distance walked on a treadmill with digitally measured proxies obtained through digital devices (such as step counters). However, these approaches overlook the richness of signal contained in full-body kinematic data and instead revert to reusing existing clinical measures. To date, the monitoring of neurodegenerative disease progression frequently fails to adequately test disease-modifying therapies because it is slow and of low precision, making drug development risky and expensive. Our digital behavioral biomarker approach promises to be of benefit to patients with rare diseases where potential disease-modifying treatments are becoming available.
2023	Darcy	Changing User	The study highlights significant shifts in

	Beckett, et al.(32)	Experience of Wearable Activity Monitors Over 7 Years: Repeat Cross-Sectional Survey Study	WAT usage, including extended use and evolving preferences for brands and features. The rise in social media sharing indicates a deeper integration of WATs into everyday life. However, user feedback points to a need for enhanced design and functionality despite technological progress. These findings illustrate WAT's potential in health promotion, emphasizing the need for user-focused design in diverse populations to fully realize their benefits in enhancing health behaviors.
2022	Ty Ferguson, et al. (33)	Effectiveness of wearable activity trackers to increase physical activity and improve health: a systematic review of systematic reviews and meta-analyses	Wearable activity trackers effectively boost physical activity and modest weight loss, with benefits lasting at least six months, supporting their use in activity promotion programs.
2022	Sophie Huhn, et al. (34)	The Impact of Wearable Technologies in Health Research: Scoping Review	Wearables are increasingly used in diverse areas—from COVID-19 prediction to rare disease monitoring—yet research in low-resource settings is lacking. They show potential for transforming population health forecasting through large-scale, data-driven studies.
2021	Caining Li, et al. (35)	Wearable activity trackers for promoting physical activity: A systematic meta-analytic review	Wearable activity trackers effectively promote conscious exercise but are less impactful on habitual behaviors. Their effectiveness depends on user type and intervention design, highlighting the need for further validation and theoretical insight.
2020	Umar A. R. Chaudhry, et al. (36)	The effects of step-count monitoring interventions on physical activity: systematic review and meta-analysis of community-based randomised controlled trials in adults.	Step-count monitoring interventions effectively improve long-term physical activity in adults, with no clear advantage of advanced trackers or added counseling over basic pedometers.
2020	Annica Kristoffer sson and Maria	A Systematic Review on the Use of Wearable Body Sensors for Health	This review qualitatively synthesizes studies on wearable body sensors across various health domains and highlights methodological and demographic gaps,

	Lindén (37)	Monitoring: A Qualitative Synthesis	identifying key shortcomings for future research improvement.
2019	Nicole Kah Mun Yoong, et al. (38)	Commercial Postural Devices: A Review	This article reviews commercial posture wearables, focusing on their clinical use in preventing, monitoring, and treating spinal and musculoskeletal conditions, as well as broader healthcare applications.
2018	Duarte Dias and João Paulo Silva Cunha, et al. (39)	Wearable Health Devices-Vital Sign Monitoring, Systems and Technologies	Wearable health devices are able to monitor a large number of vital signs of human body, from advance sensor supervision in the case of infant respiratory to fitness applications or even soldiers on the battlefield. This particularity of WHDs creates a big excitement around this technology and many opportunities to continue its development.
2017	Giorgio Biagetti, et al. (40)	Human activity monitoring system based on wearable sEMG and accelerometer wireless sensor nodes	A low-cost wireless system for the acquisition of sEMG and accelerometer signals has been presented for healthcare and fitness applications. The system consists of wearable sensing nodes that wirelessly transmit the biological and accelerometer signals to one or more stations. The signals so acquired will be combined and processed in order to detect, monitor and recognize human activities
2016	Jaewoon Lee, et al. (41)	Sustainable Wearables: Wearable Technology for Enhancing the Quality of Human Life	This paper briefly summarizes wearable applications in wellness, healthcare, disaster relief, and disability support. It highlights wearables' role in extending human capabilities, emphasizing their potential to improve individual quality of life and benefit society. Future wearables should move beyond mere accessories to serve meaningful, impactful purposes.
2015	Ryan T. Li, et al. (42)	Wearable Performance Devices in Sports Medicine	Wearable devices are valuable instruments for the improvement of sports performance. Evidence for use of these devices in professional sports is still limited. Future developments are needed to establish training protocols using data from wearable devices.

Results

We conducted a comprehensive search of relevant literature and included only those studies that met our predefined inclusion and exclusion criteria. All authors participated in boundary screening to ensure that no pertinent articles were overlooked. The final set of included studies underwent detailed analysis, covering aspects such as sample size, methodology, evaluation approaches, research findings, CASP assessments, and checklist scores (Table 3).

Study Characteristics

A total of 15 studies were included in this review, with most published between 2015 and 2022, reflecting the increasing interest in wearable technologies for health monitoring and physical activity promotion. Most of the studies were conducted in high-income countries, including the United States, Australia, Germany, Sweden, Japan, and China. Only a limited number of studies involved low- and middle-income countries, highlighting a potential geographical gap in research and adoption of wearable technologies.

In terms of study design, the included articles comprised systematic reviews (n=6), randomized controlled trials (n = 4), prototype or feasibility studies (n=3), and technical development papers (n = 2). Sample sizes varied greatly, with some studies reporting fewer than 50 participants, while others synthesized findings from thousands of individuals across multiple trials.

Study populations included healthy adults, patients with chronic conditions (e.g., cardiovascular disease, diabetes), rehabilitation patients, and athletes. However, pediatric and older adult populations were underrepresented across the studies.

A diverse range of wearable devices was examined, including activity trackers, smart textiles, in-shoe pressure sensors, surface EMG systems, and epidermal biosensors. These devices measured parameters such as heart rate, step count, movement patterns, skin temperature, and oxygen saturation. Monitoring environments included clinical settings, community-based trials, home use, and aquatic exercise environments.

Wearable Technology in Medical Rehabilitation

With the rapid advancement of wearable technologies, activity trackers have seen widespread adoption, empowering both researchers and clinicians to investigate the nuanced relationships between physical activity patterns and a wide array of health outcomes. Modern wearable systems are no longer limited to basic step counts or heart rate monitoring; instead, state-of-the-art devices increasingly feature integrated sensing and therapeutic functionalities, incorporating high-sensitivity, multimodal sensors capable of capturing complex physiological and biomechanical signals. These systems are particularly valuable in the context of medical rehabilitation, where continuous monitoring enables personalized therapeutic strategies and more precise health assessments.

In recent years, a growing body of research has focused on the application of wearable technologies in rehabilitation settings—particularly for improving the quality of life among older adults and individuals living with chronic neurodegenerative or neuromuscular conditions, such as Parkinson's disease, post-stroke disability, and dementia (47,53). The

central goal of these interventions is to facilitate continuous, real-time tracking of patient health status and behavior, enabling early detection of symptom exacerbation and dynamic monitoring of disease progression. This real-time feedback loop supports clinicians in making informed decisions and empowers patients to sustain greater independence in their daily routines.

To meet these clinical objectives, wearable sensors are strategically deployed on the patient's body to capture a range of physiological parameters, including but not limited to:

- Heart rate and heart rate variability (HRV)
- Blood pressure
- Peripheral blood oxygen saturation (SpO₂)
- Respiratory rate
- Core and peripheral body temperature
- Electrodermal activity (skin conductance)
- Arterial pulse waveforms (via wrist or fingertip PPG sensors)
- Jugular venous pulse (JVP) estimation in specific designs

These continuous physiological measurements can serve as critical diagnostic indicators and are often used to trigger automated alerts when readings deviate from patient-specific thresholds. Such capabilities are especially vital in post-acute or long-term care settings, where subtle physiological changes may precede clinical deterioration.

In addition to supporting clinical teams, wearable technologies also enhance communication and caregiving for patients' families. Remote access to real-time data allows caregivers to track vital signs and physical activity patterns, ensuring that unexpected changes—such as increased fall risk, cardiovascular anomalies, or behavioral changes—are promptly addressed. In post-discharge scenarios, this data-driven oversight significantly reduces the likelihood of unnoticed deterioration, thereby contributing to reduced hospital readmission rates and more stable outpatient recovery trajectories.

In summary, wearable technologies are reshaping the landscape of medical rehabilitation by providing continuous, unobtrusive, and clinically actionable monitoring. These advancements not only improve health outcomes for individuals with chronic conditions but also enable a more proactive, personalized, and decentralized model of care.

Application Scenarios

Sports Monitoring

Wearable devices are increasingly utilized in sports settings for training surveillance, performance optimization, and injury prevention. Li et al. (2015) reviewed the application of wearable performance devices in sports medicine and highlighted their potential in enhancing athletic training by enabling real-time feedback on physiological and biomechanical parameters (42). However, they noted that empirical evidence supporting their effectiveness in professional sports remains limited, and standardized training protocols are still lacking.

Chronic Disease Management

Wearable technologies have shown promise in supporting the management of chronic diseases

by enabling continuous physiological monitoring and encouraging self-management behaviors. Kristoffersson and Lindén (2020) synthesized evidence on the use of wearable body sensors across various chronic conditions, including asthma, cardiovascular disease, diabetes, and neurological disorders (37). Their review revealed that although wearable devices were frequently applied in these areas, gaps remained in study quality, participant diversity, and consistency of measurement outcomes.

Similarly, Ferguson et al. (2022) found that wearable activity trackers were effective in promoting physical activity across both clinical and non-clinical populations (25). While their impact on weight and exercise adherence was modest but meaningful, the effects on broader physiological and psychological outcomes were less consistent.

Wearable devices have been applied in medical rehabilitation to support movement analysis, monitor recovery progress, and facilitate patient engagement. Biagetti et al. (2017) developed a wireless system using surface electromyography (sEMG) and accelerometers to track muscle activity and movement in real time (40). This system was designed for both healthcare and fitness applications, with potential utility in physical rehabilitation programs requiring fine-grained motion tracking.

Challenges and Future Directions

Wearable technology holds immense promises in the field of digital health, yet several shared challenges continue to impede its full-scale deployment. One of the foremost issues is data accuracy and reliability. Physiological data collected by wearable sensors are often affected by environmental factors and individual variability, leading to measurement errors. For example, optical sensors can be influenced by skin pigmentation and motion artifacts, compromising signal quality. In addition, the lack of standardized protocols and interoperable systems across different devices hinders clinical integration and comparative analysis.

User adherence and long-term acceptance remain problematic. Factors such as discomfort, operational complexity, and privacy concern discourage sustained use. Some users may experience anxiety due to constant health feedback or feel dissatisfied with device performance. Moreover, technical limitations—including limited battery life, incomplete sensor miniaturization, and real-time data processing constraints—further restrict their application, especially in remote health monitoring scenarios.

Data privacy also poses a major concern, as wearable devices collect large volumes of sensitive personal health data. Ensuring secure data storage and transmission is crucial for building trust and expanding adoption. Looking ahead, future research and development must address these issues by integrating multimodal data sources and applying intelligent analytics to derive deeper insights. Advanced AI models could improve the accuracy of fatigue, stress, or disease detection and support individualized health prediction. Wearable systems should also evolve to provide real-time personalized health alerts and risk warnings based on dynamic physiological signals.

Enhancing wearability through flexible materials and battery optimization will support sustainable use, while well-designed feedback mechanisms may reduce anxiety and improve engagement. Finally, establishing unified data standards and robust privacy frameworks will be essential to ensure interoperability and secure information exchange across platforms. With continued interdisciplinary innovation, wearable technology is expected to evolve into

intelligent, precise, and user-centered tools for proactive health management and personalized care.

Discussion

Wearable technology plays an increasingly important role in promoting physical activity, monitoring health status, and supporting rehabilitation. As health awareness grows, more individuals rely on wearable devices to track exercise, manage chronic conditions, and prevent future health risks. Compared with traditional clinical monitoring, wearables offer continuous, real-time feedback in a user-friendly form, helping users better understand their physical condition and encouraging healthy behavior (25).

Wearable devices offer several notable advantages. They are highly integrated systems that use computer-assisted technology to capture real-time information about the body's functional status and can simultaneously monitor multiple physiological parameters. They also provide timely feedback on the user's current condition, which can enhance an individual's motivation to exercise. By monitoring various aspects of health and behavior through wearables, individuals are able to track their progress toward personal goals and maintain healthier lifestyle habits (54).

Highly Integrated Wearable Systems

Wearable devices function as self-management and self-monitoring technology platforms built on human-centered design principles. A primary conclusion from our results is that wearable devices enable comprehensive monitoring of human physiological signals (55). Many modern wearables not only possess monitoring functions but can also utilize the collected data for predictive analysis via advanced computing techniques (20,56).

Early generations of wearable devices could measure only basic metrics such as heart rate and step count. While these were easy to track, we found that the data often contained considerable errors, making it difficult for users to accurately evaluate their health status based on such readings. Accurate monitoring and health assessment historically were achievable only in clinical settings. However, with the development of wearable technology, current devices provide an integrated self-monitoring platform that can comprehensively and accurately track personal physiological information (57). They capture vital signs (heart rate, blood pressure, body temperature) and other health indicators through integrated sensors and biosignals (for example, ECGs, BCGs, blood oxygen saturation, hydration levels, sleep patterns, etc.). Having accurate knowledge of one's current physical condition – and being able to act on that information to improve daily habits – can directly lead to better health outcomes.

For example, wearable devices can collect a wealth of data from the user's environment and body, including (but not limited to) bioelectrical signals from muscles, muscle strength, and sleep states (58). These data provide important insights for evaluating and refining the design of smart wearables to improve their efficacy. Moreover, developers have created virtual testing environments and detailed monitoring tasks to better assess the accuracy and trends of data collected by wearables (59). In essence, wearable technology serves as an assistive tool capable of real-time physiological monitoring and analysis. The field is moving away from simply amassing large quantities of raw data and toward highly integrated, computer-filtered information that can be more directly used for health assessment. Additionally, by leveraging

sophisticated computing technology, wearables are now extending their predictive capabilities. Such devices can inform users how their current lifestyle and physical status may affect their future health or functional abilities over time, and they can offer personalized recommendations for improvement. This integration of real-time monitoring with predictive analytics enables users to engage in sustainable exercise regimens and gradually improve their health.

Psychological Aspects of Wearable Use

From the perspective of improving personal health, the purpose of monitoring physiological information is not only to inform users of their current physical status but also to encourage positive behavior change through motivational or reward mechanisms (60). Many health issues fundamentally stem from poor lifestyle and exercise habits, and simply tracking biological signals is not enough to overcome these issues. Research suggests that positive incentives can accelerate the improvement of physical health, whereas purely passive interventions often fail to achieve optimal well-being (61). Wearable devices can provide stepwise training programs or incorporate reward systems to increase users' psychological satisfaction as they complete workouts, which in turn helps them adhere to—and even look forward to—their training or rehabilitation routines. Developers have started integrating fitness challenges and reward-based tasks into wearables aimed at improving users' physical condition (62). Enhancing feedback during training (for example, showing users how consistent exercise can extend their longevity or demonstrating what activities they can achieve given their current fitness level) has been shown to help users become more proactive and engaged in their exercise regimen (63).

A key concern for users is maintaining a positive mindset toward exercise, since low motivation can greatly undermine rehabilitation and training outcomes (leading to wasted time or repeated setbacks in health). Wearable technology can dynamically adjust exercise difficulty, goals, and feedback during physical activity to reduce negative psychological responses - such as feelings of helplessness or fatigue - that often arise over long-term training. In addition to influencing the way people exercise and helping them plan for long-term health improvements, wearable devices thus also contribute to fostering a positive training mindset for users.

Future Challenges

Based on our findings and analysis of relevant factors, we gained a deep understanding of how wearable technology can influence user engagement and boost exercise motivation during training. Our results highlight three tangible advantages of wearable devices: their practical utility for stakeholders, their ability to provide highly integrated data monitoring, and their capacity for long-term tracking. However, there are still several challenges that must be addressed in future research and development in this field.

Wearable-guided exercise and rehabilitation programs have the benefit of becoming more personalized for each user. We must consider the fundamental purpose of such training: namely, to improve or restore individuals' physical function and strengthen their health (for example, by boosting immunity). While wearable monitoring devices are effective at tracking physiological metrics, it remains difficult to change users' adherence to training programs or to overcome their neglect of personal health conditions (64). In essence, one core goal for wearable technology is to enhance users' intrinsic motivation for exercise and rehabilitation,

alongside providing precise real-time monitoring of their physiological traits (65).

It is worth noting that earlier generations of wearables were mostly used for patients under clinical supervision, where continuous vital sign monitoring was required to prevent acute health deteriorations. Given the current state of wearable monitoring technology, there is still no research evidence directly indicating that wearables can improve physical health simply by increasing the frequency of exercise activities. Future studies should further explore the benefits of structured exercise programs facilitated by wearables, as well as the sustainability of wearable device use and its long-term impact on health outcomes. This need is underscored by the fact that improvements in an individual's health are ultimately manifested in the physiological data that wearables aim to monitor. Therefore, future work should provide more direct evidence to demonstrate that wearable technology can enhance the effectiveness of training regimens and improve physical function. Additionally, greater attention should be devoted to how computing systems can accurately monitor, filter, and analyze the vast physiological data generated by wearables – this integration of data science and health monitoring remains an unresolved challenge.

Study Limitations

This review has several limitations. First, the number of studies we included was limited, which constrains the generalizability of our results. In future reviews, we will expand the inclusion of studies and undertake a deeper investigation to strengthen the evidence base. Second, most of the studies we reviewed had small sample sizes or short intervention durations; our findings therefore highlight the necessity for longer-term studies and larger-scale trials. The heterogeneity in study designs also introduces statistical variability in the results. Third, it is difficult to determine the independent contribution of ancillary interventions often provided alongside wearable tracker use (for example, behavioral counseling, interactive health coaching, weekly reminders, or text messaging) to the outcomes observed. Although we established specific screening criteria for study inclusion, we cannot entirely rule out the influence of other confounding factors on the findings.

Conclusions

In this systematic review, we found that wearable sensors and monitoring devices can provide real-time, continuous tracking of personal physiological data in contexts ranging from everyday health monitoring to medical rehabilitation. This capability enables individuals to manage their own health more accurately and proactively. Our review underscores the significant potential of wearable technology to enhance personal health monitoring and exercise management. However, realizing the full value of these innovations will require further technical advances and the resolution of current limitations. By addressing issues such as device comfort, measurement accuracy, data privacy, and data integration, wearable devices can evolve into transformative tools for personalized health care and improved long-term wellness outcomes.

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Please

Conflicts of Interest

None declared.

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Abbreviations

BCG: ballistocardiogram

CASP: Critical Appraisal Skills Programme

ECG: electrocardiogram

JVP: Jugular venous pulse

PPG: photoplethysmography

sEMG: surface electromyography

Data availability statement

This statement can be excluded as the study did not report any data.

Ethics approval

Not applicable.

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