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Wearable Devices as Tools for Better Hypertension Management in Elderly Patients

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Background: Hypertension is a growing global health concern, particularly among the elderly, and is a significant contributor to cardiovascular and cerebrovascular diseases. Managing hypertension in elderly patients is particularly challenging, requiring continuous monitoring and strict adherence to treatment protocols. This study aimed to evaluate the effectiveness of integrated management strategies that utilize wearable devices in enhancing hypertension management for elderly patients.

Material/Methods: A total of 400 elderly patients with primary hypertension from the People's Hospital of Pudong New Area, Shanghai, and the Heqing Community Health Service Center were selected from September 2022 to November 2023. These patients were randomly assigned to either an experimental group or a control group. The experimental group used a chronic disease management platform based on wearable devices, which enabled real-time monitoring and personalized interventions. The control group received traditional hypertension management.

Results: The experimental group achieved significantly better outcomes across multiple areas compared to the control group, including improved medication adherence, enhanced blood pressure control, and better quality of life encompassing overall health, physical, social, and emotional functions. Additionally, the experimental group showed enhanced knowledge of hypertension and superior self-management abilities, covering aspects such as diet, medication, and emotional management.

Conclusions: This study highlights the potential of wearable device-based chronic disease management platforms in significantly improving hypertension control, treatment adherence, quality of life, and self-management capabilities among elderly patients. The findings suggest that such technology-driven solutions can address the challenges of hypertension management in elderly populations, providing a critical tool for long-term disease management.

Keywords: Aging • Hypertension • Wearable Electronic Devices

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Introduction

Hypertension is a significant global public health issue, acting as a major risk factor for cardiovascular and cerebrovascular diseases and potentially leading to serious conditions such as renal insufficiency and heart failure. Current estimates indicate that approximately 1.5 billion individuals worldwide are affected by hypertension, a number that is steadily increasing [1-3]. Projections suggest that due to aging populations and lifestyle changes, the global hypertensive population will reach 1.56 billion by 2025 [4]. Among elderly patients, the impact of hypertension is particularly profound, as it contributes to heightened risks of comorbidities, reduced functional capacity, and an overall decline in quality of life. Addressing hypertension in this demographic thus requires tailored management strategies that account for age-specific challenges.

In China, the prevalence of hypertension is particularly severe, with a noticeable trend towards older age groups. This condition significantly impacts the quality of life for patients and poses a major challenge to the global public health system [5,6]. Given the high rates of disability and mortality associated with hypertension, the need for effective prevention and control measures is urgent. However, traditional approaches to hypertension management often face hurdles, including low patient compliance and limited healthcare provider engagement, especially in elderly populations.

A survey published in The Lancet revealed that nearly half of the adult population in China suffers from hypertension, yet the rates of treatment and control are exceedingly low, highlighting a critical issue of "one high and three lows" (high prevalence, low awareness, low treatment rate, low control rate) [7]. Thus, improving patient adherence to treatment and promoting lifestyle changes are crucial steps in addressing this public health challenge.

The rapid advancement of society and continuous innovation in information technology are transforming medical services, especially into hypertension management where community-based prevention strategies are gaining importance. Traditional management approaches, however, face challenges such as insufficient interaction between patients and healthcare providers [8]. Wearable devices have emerged as a promising solution to overcome these barriers. By providing continuous monitoring and fostering active engagement, these technologies have the potential to revolutionize patient adherence, optimize healthcare delivery, and enhance long-term outcomes, particularly among the elderly. Recent advancements in wearable health technology have further highlighted their effectiveness in chronic disease management, particularly for conditions like hypertension, diabetes, and cardiovascular diseases [9]. The integration of wearable devices in chronic disease management has been shown to enhance patient engagement and facilitate continuous health monitoring [10].

In response to these challenges, a collaborative effort between the People's Hospital of Pudong New District in Shanghai and the Heqing Community Health Service Center has led to the development and implementation of a hypertension management system based on wearable devices. This study explicitly aims to evaluate the comparative effectiveness of traditional and wearable device-enhanced management models, focusing on metrics such as patient awareness, control rates, treatment adherence, and lifestyle improvements. By leveraging empirical analysis, the research seeks to demonstrate the feasibility and benefits of integrating wearable technology into hypertension care, particularly for elderly patients. These insights are expected to contribute to broader public health initiatives by offering scalable solutions for chronic disease management and advancing the integration of digital health tools in routine clinical practice.

Material and Methods

This study was conducted between September 2022 to November 2023 at the Department of General Medicine of Pudong New District People's Hospital in Shanghai and the Heqing Community Health Service Center. A total of 400 patients diagnosed with primary hypertension were selected based on established inclusion and exclusion criteria. We employed a randomized controlled trial design, selected for its robustness in minimizing biases and enhancing the reliability of comparative analyses and these patients were randomly allocated to either the experimental group or the control group, each consisting of 200 participants. Randomization was performed using a random number table. In the control group, there were 120 male and 80 female patients, aged between 60 and 80 years, with a mean age of 67.5±7.3 years. The duration of their hypertension ranged from 3 to 15 years, with an average of 8.9±2.1 years. The observation group comprised 122 male and 78 female patients, aged between 61 and 81 years, with a mean age of 68.4±7.2 years. The duration of their hypertension ranged from 4 to 16 years, with an average of 9.0±2.2 years. A comparison of baseline characteristics, including age, gender distribution, and duration of disease, showed no statistically significant differences between the 2 groups (all $P>0.05$), confirming their comparability. The study received approval from the hospital's medical ethics committee, and all participants provided written informed consent.

Ethics Approval and Consent to Participate

This study was approved by the ethical committee of Shanghai Pudong New Area People's Hospital (2022-K90). All participants were fully informed about the content of the research and provided written informed consent before participating.

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Inclusion and Exclusion Criteria

Inclusion Criteria

1) The target participants must be permanent residents of the Heqing community, expected not to relocate within the next year. 2) Diagnosed with primary hypertension based on authoritative medical guidelines, such as those outlined in 'Internal Medicine,' with current blood pressure levels remaining above the target treatment goal. 3) Age range set from 30 to 70 years, covering the middle-aged and elderly hypertensive patient population. 4) Relatively stable cardiac and renal functions, i.e., cardiac function classified at Class II or below, and a glomerular filtration rate (GFR) higher than 60 ml/min/1.73m^2, ensuring no severe cardiac or renal dysfunction. 5) Mentally clear, capable of effective communication, and able to express their own wishes. 6) Explicitly willing to participate in the study and have signed an informed consent form. 7) Possess and are proficient in operating a smartphone, enabling the use of mobile medical applications for blood pressure monitoring and data logging.

Exclusion Criteria

1) Patients with secondary hypertension, due to its complex etiology, different treatment, and management strategies from primary hypertension. 2) Residents planning to move out of the Heqing community within a year, as it might affect the continuity and integrity of the study. 3) Individuals with mental illness or cognitive impairments, unable to understand the research requirements or follow the study protocol. 4) Individuals with severe cardiac, pulmonary dysfunction, or significant liver and kidney function impairment, as these conditions may affect hypertension management. 5) Individuals who have undergone chemotherapy or radiotherapy for tumors in the past 6 months, as the treatment process might affect blood pressure levels. 6) Individuals unable to read or write, or do not possess a smartphone, as this would affect their participation in app-based blood pressure monitoring. 7) Women who are currently pregnant or planning to become pregnant in the near future, given the unique requirements for managing blood pressure during pregnancy. 8) Individuals do not demonstrate a positive willingness to participate in the study, ensuring the enthusiasm and cooperation of the study participants.

Study Equipment

Wearable Device (Blood Pressure Monitor): The Lox i7 electronic blood pressure monitor (model: LS805) from Guangdong Lox Medical Electronics Co., Ltd. The accuracy and stability of this device have been certified by authoritative national agencies in China.

Management Methods

In this study, patients in the experimental group used a smart blood pressure monitor, which connects to a smartphone via Bluetooth and integrates with WeChat, a mobile application developed by Tencent, enabling automatic uploading of blood pressure data to a chronic disease management information platform and cloud platform. This platform allows the medical team to monitor the data in real-time and manage it at a personalized level. Immediate remote medical interventions, including medication adjustments and lifestyle guidance, are initiated upon detection of abnormal blood pressure readings. Additionally, the experimental group regularly receives hypertension management knowledge and psychological support information sent via WeChat. The control group maintains the traditional public health management approach, with regular blood pressure measurements, face-to-face health education at the community health service center, and regular follow-ups via phone or home visits to monitor and guide the patients' blood pressure management. This comparative study aims to evaluate the effectiveness of a hypertension management model that utilizes wearable devices and information technology, compared to traditional methods, in enhancing self-management capabilities and blood pressure control in hypertensive patients.

Observation Indicators

Hypertension Treatment Rates and Medication Adherence

The assessment of hypertension treatment rates and medication adherence in this study involves a detailed analysis to determine the effectiveness of the implemented management strategies. The hypertension treatment rate is calculated as the percentage of hypertensive patients meeting the target blood pressure (BP) of less than 130/80 mmHg, relative to the total number of hypertensive patients enrolled in the survey. This metric provides a quantifiable measure of the adherence level within the patient population. Additionally, patient adherence to treatment is evaluated using the Morisky Medication Adherence Scale (MMAS-8), which offers a structured approach to gauge consistency and reliability with which patients follow their prescribed medication protocols. This scale encompasses various dimensions of adherence, including forgetfulness and discontinuation of medication when feeling better, thus offering a comprehensive overview of adherence behavior.

Quality of Life

To assess the quality of life in both the experimental and control groups before and after the intervention, we utilized the Short Form Health Survey (SF-36). This survey assesses 8 dimensions of health; however, for the purposes of this study, we focused on 4 dimensions closely related to our research

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objectives: general health, physical functioning, social functioning, and emotional well-being. The SF-36 generates scores ranging from 0 to 100, where higher scores represent a better quality of life. By comparing these scores pre- and post-intervention, we aim to elucidate the specific impact of the intervention measures on enhancing the participants' quality of life.

Knowledge Level on Hypertension

To assess the participants' knowledge level on hypertension, a simplified self-administered disease knowledge questionnaire was employed. This instrument was designed to gauge the participants' understanding across several critical domains related to hypertension. The questionnaire addressed various aspects including the diagnostic criteria for hypertension, the techniques for measuring blood pressure, the normal range of blood pressure values, and medication-related knowledge. Furthermore, it included questions on healthy dietary suggestions, principles of appropriate medication usage, weight management strategies, and methods to reduce smoking and alcohol consumption. Additionally, the questionnaire covered the understanding of potential complications associated with hypertension and the importance of regular follow-up visits. The questionnaire consisted of 20 questions, each offering a straightforward scoring system where one point was awarded for each correct response, while incorrect or unanswered questions received no points. This scoring method allowed for a quantifiable measure of the participants' knowledge levels, with higher total scores indicating a more comprehensive understanding of hypertension. This tool was crucial in determining how well the participants grasped the essential information required to effectively manage and control hypertension.

Self-Management Efficacy

The General Self-Efficacy Scale (GSES), originally developed by Schwarzer and colleagues, was employed to measure self-management efficacy. The Chinese version of this scale, adapted by Zhang and colleagues, was utilized. This scale comprises 10 items, each rated on a four-point Likert scale ranging from "not at all true" to "exactly true," with corresponding scores from 1 to 4. The GSES is a unidimensional instrument, meaning that all items measure a single construct. The overall score is calculated as the average of the 10 item scores. A higher average score indicates a greater level of perceived self-efficacy, reflecting the individual's confidence in their ability to manage their own health effectively.

Power Analysis

The sample size of 400 participants was determined using a priori power calculations to detect a clinically meaningful difference in hypertension management outcomes between the experimental and control groups. The primary outcome measure was the proportion of patients achieving target blood pressure control. Assuming an effect size of 0.3 (moderate improvements in blood pressure management), a two-tailed significance level (α=0.05), and a desired power (1-β=0.80), the required sample size was calculated using the formula:

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \cdot (p_1(1 - p_1) + (p_2(1 - p_2))}{(p_1 - p_2)^2}$$

Where p_1 and p_2 are the expected proportions in the control and experimental groups, respectively, $Z_{\alpha/2}$ is the critical value of the standard normal distribution corresponding to a two-tailed test at α=0.05 (1.96), and Z_{β} is the critical value corresponding to β=0.20 (0.84).

Based on these parameters and an expected improvement in blood pressure control of 8-12%, based on previous studies, the required sample size was calculated to be 362 participants. To account for potential dropout or incomplete data collection, an additional 10% was added, resulting in a final sample size of 400 participants. This ensures sufficient statistical power to robustly evaluate the effectiveness of the intervention.

Statistical Analysis

Statistical analysis was conducted using SPSS software version 26.0. Measurement data are expressed as mean±standard deviation ($\bar{\chi}\pm S$). For data conforming to a normal distribution, the t-test was employed, while the Mann-Whitney U test was used for data not following normal distribution. Count data were presented as frequencies, and comparisons between groups were made using the Chi-square test (χ^2 test). A P-value of less than 0.05 was considered statistically significant.

Results

Efficacy of Hypertension Management Strategies and Medication Adherence

The efficacy of hypertension treatment rates and medication adherence was evaluated by comparing the experimental group, which utilized a chronic disease management information platform that involves wearable devices, to the control group that followed traditional management methods. As detailed in **Table 1**, the blood pressure control rate in the experimental group was significantly higher (80.5%) compared to the control group (60.5%), clearly indicating the intervention's success. The medication adherence scores showed a remarkable increase in the experimental group, alongside notable improvement in the control group, as illustrated in **Figure 1**. The experimental group exhibited a more pronounced degree of improvement relative to the control group (mean difference=5.55,

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Table 1. Comparison of hypertension treatment rates and medication adherence.

Group	N	BP targets met	Treatment rate
Control	200	121	60.50%
Experimental	200	161	80.50%

	Medication adherence		P_1	P_2
	Before	After		
Control	9.07±2.15	16.65±2.45	P<0.05	
Experimental	9.10±2.05	22.20±2.60	P<0.05	P<0.05

BP – blood pressure. P_1 indicates comparison within group before intervention; P_2 indicates comparison with the control group after intervention.

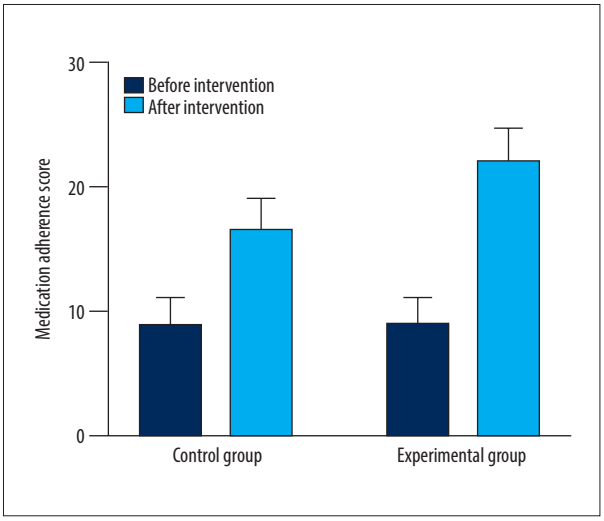

Figure 1. Comparison of medication adherence scores before and after intervention.

95% CI: 5.05-6.05, P<0.05). However, the experimental group exhibited a more pronounced degree of improvement relative to the control group (P<0.05). This data underscores the effectiveness of the chronic disease management information platform in enhancing both the blood pressure control rate and medication adherence among hypertensive patients. The intervention's positive impact on managing hypertension was evident, showcasing the potential of such system in chronic disease management.

Improvements in Patients' Quality of Life Following Intervention

Quality of life scores, as measured across multiple dimensions (**Table 2**), also improved significantly in the experimental group (mean increase: 19.21; 95% CI: 19.02-19.40) compared to the control group (mean increase: 10.07; 95% CI: 10.00-10.14). These improvements were observed across 4 key dimensions: overall health, physical function, social function, and emotional role. Statistical analysis confirmed that the enhancements in these dimensions were statistically significant when comparing pre- and post-intervention results within the experimental group. Furthermore, a comparison between the experimental group and the control group post-intervention demonstrated statistically significant improvements in the experimental group (P=0.001). These findings suggest that the chronic disease management information platform has a positive

Table 2. Comparison of patient quality of life.

Group	N	Overall health		Physical functioning		Social functioning		Emotional roles	
		Before	After	Before	After	Before	After	Before	After
Control	200	74.16±0.28	84.23±0.52	70.13±0.87	82.31±0.41	65.53±0.40	78.57±0.05	61.28±1.18	74.90±1.66
Experimental	200	74.25±0.33	93.46±1.37	70.17±0.96	88.35±1.78	65.48±0.37	86.26±2.39	61.22±1.23	85.54±2.71
P_1			<0.05		< 0.05		<0.05		<0.05
P_2		0.223	0.001	0.856	0.001	0.589	0.001	0.836	0.001

P_1 indicates comparison within group before intervention; P_2 indicates comparison with the control group after intervention.

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Table 3. Comparison of patients' mastery of hypertension knowledge.

Group	N	Hypertension knowledge score	
		Before	After
Control	200	14.15±1.41	17.68±1.25
Experimental	200	13.78±1.55	18.29±1.56
P		0.189	0.036

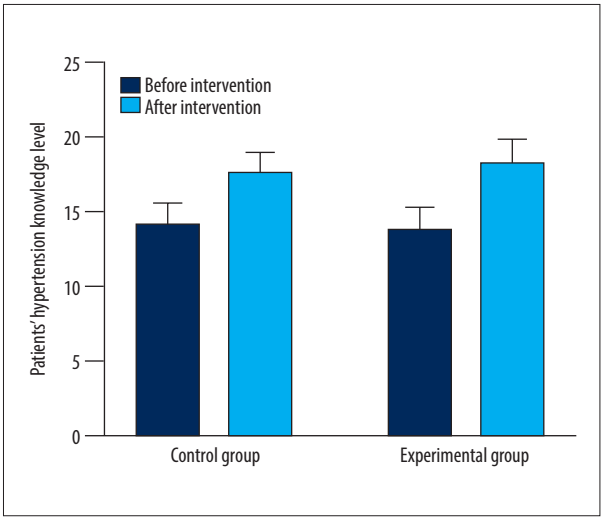

Figure 2. Comparison of patients' mastery of hypertension knowledge levels.

and effective impact on enhancing the quality of life for patients with hypertension, particularly in improving their overall health, physical function, and social and emotional roles.

Impact of Interventions on Patients' Hypertension Knowledge

Our analysis demonstrates an improvement in the hypertension knowledge scores among patients in both the experimental and control groups following the intervention (**Table 3**). Initially, there was no significant difference in knowledge scores between the 2 groups (P=0.189). This indicates that both groups started with a comparable baseline level of hypertension knowledge. However, post-intervention results reveal a notable change. The experimental group, which received specific intervention measures through the chronic disease management information platform, showed a substantial improvement in their hypertension knowledge compared to the control group (P=0.036).

Specifically, the mean knowledge score in the experimental group increased from 13.78 (95% CI: 13.57-13.99) to 18.29 (95% CI: 18.07-18.51), while the control group demonstrated a more modest increase from 14.15 (95% CI: 13.95-14.35) to 17.68 (95% CI: 17.51-17.85). This data underscores the efficacy of the chronic disease management information platform over traditional methods in educating patients about hypertension management. The platform's targeted educational content and interactive features likely contributed to a deeper and more comprehensive understanding among the patients, as shown in **Figure 2**, reinforcing the conclusion that digital interventions can effectively enhance patient knowledge and empower them with the necessary information to better manage their condition.

Enhanced Self-Management Efficacy Through a Chronic Disease Management Platform

The intervention measures facilitated through the chronic disease management information platform led to a marked improvement in self-management efficacy among patients in the experimental group, as illustrated in **Table 4**. Specifically, significant enhancements were observed in areas such as diet, medication adherence, emotional management, work and rest balance, physical activity, and condition monitoring. For dietary regulation, the mean improvement in efficacy was 4.08% (95% CI: 3.65-4.51; P<0.001), while for work and rest balance, the mean improvement was 2.92% (95% CI: 2.69-3.15; P<0.001). Physical activity and condition monitoring showed moderate gains, with mean improvements of 1.17% (95% CI: 1.00-1.34; P<0.001) and 2.82% (95% CI: 2.59-3.05; P<0.001), respectively. In contrast, while the control group exhibited some improvements, these changes were modest and lacked statistical significance in most cases. For example, the improvement in dietary regulation for the control group was 4.08% (95% CI: 3.65-4.51; P=0.07). This comparative analysis underscores the effectiveness of the chronic disease management information platform in bolstering the self-management capabilities of patients with hypertension. The platform's impact is notably positive, contributing to an enhanced quality of life for these patients. The findings highlight the potential of such technology-driven management systems in improving health outcomes for individuals with chronic conditions, emphasizing the importance of integrating advanced health management tools in routine care practices.

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Table 4. Comparison of patients' self-management efficacy.

Group	N	Dietary management		Medication management		Emotional management	
		Before	After	Before	After	Before	After
Control	200	34.36±1.85	35.48±1.78	12.56±2.45	14.85±1.20	24.61±2.15	24.65±1.75
Experimental	200	34.58±1.75	38.66±3.05	12.85±2.65	16.15±2.54	22.65±2.34	25.31±1.26
T		0.256	6.634	0.587	3.057	1.445	1.485
P		0.794	<0.001	0.561	0.003	0.142	0.136
Group	**N**	**Work and rest management**		**Exercise management**		**Disease monitoring**	
		Before	After	Before	After	Before	After
Control	200	18.69±2.36	19.25±1.63	10.56±1.32	10.85±1.16	10.07±1.05	11.65±0.68
Experimental	200	19.06±2.68	21.98±1.65	11.18±1.68	12.35±1.25	10.26±1.69	13.08±1.68
P		0.542	<0.001	0.015	<0.001	0.541	<0.001

Discussion

Hypertension is a significant global public health issue, exacerbated by societal aging and lifestyle changes [11]. Particularly in China, the rapid aging population and vast population have led to a significant increase in hypertension cases, putting immense pressure on the public health system [12,13]. Traditional management strategies, primarily relying on hospital and outpatient services, are often limited in effectiveness due to uneven distribution of medical resources, varying patient disease awareness, and challenges in modifying lifestyle habits [14-16]. Effective hypertension management should integrate factors such as medication, lifestyle adjustments, and regular monitoring, requiring continuous patient participation [17-19]. Advancements in information and medical technologies, such as wearable devices and mobile health (mHealth) technologies, have significantly enhanced management efficiency and convenience [20]. These technologies can continuously monitor blood pressure changes, provide timely feedback, and assist in early detection of issues and adjustment of treatment plans [21,22]. This study aimed to evaluate the effectiveness of a management strategy for elderly hypertension patients using wearable devices, integrating advanced information technologies for real-time monitoring and data analysis, and offering comprehensive health management solutions.

The results confirmed that patients in the experimental group, supported by wearable technology, achieved significantly better blood pressure control than those in the control group. These findings align with prior research emphasizing the efficacy of telemonitoring and digital health interventions in improving hypertension management [23-25]. Continuous data transmission from wearable devices enabled timely medical adjustments and personalized care, which likely promoted these improved outcomes. Notably, medication adherence in the experimental group also improved, consistent with previous studies showing structured patient engagement and feedback mechanisms enhance adherence [1,26]. The ability of wearable devices to provide reminders and monitor adherence was a critical factor in fostering compliance [27-29].

The experimental group also reported significant quality of life improvements across various dimensions, corroborating evidence that telehealth interventions reduce the chronic disease burden [20,30]. Wearable devices, by offering real-time feedback and personalized support, have been shown to enhance adherence and quality of life in chronic conditions such as hypertension and diabetes [31,32]. The platform's continuous support, educational resources, and psychological reinforcement empowered patients to manage their condition more effectively. Additionally, the intervention significantly increased patients' knowledge of hypertension management, highlighting the value of targeted education in chronic disease care [8,33]. The improvement in self-management behaviors observed among experimental group patients further supports the role of wearable technologies in fostering patient autonomy [14,30].

Beyond hypertension, the functionalities of wearable devices – such as real-time monitoring and personalized feedback – could extend to managing other chronic conditions, including diabetes, cardiac health, weight management, and post-surgical rehabilitation. These applications underscore the adaptability of wearable technologies in public health interventions.

Despite these promising outcomes, challenges persist. The scalability of wearable interventions introduces cost-effectiveness concerns, including initial expenses for devices, maintenance,

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and training. Economic disparities might limit access, exacerbating health inequities. Long-term, however, improved management and complication prevention could offset costs, making these technologies a strategic investment.

Ethical issues, particularly around data privacy, warrant attention. Wearable devices collect sensitive health data, necessitating robust security measures and clear informed consent processes, especially for elderly and vulnerable populations. Transparent communication and stringent regulatory oversight are crucial for addressing these concerns.

Adoption barriers also exist, particularly for elderly users unfamiliar with digital technologies. Programs to enhance digital literacy and provide training are essential but resource-intensive. Integrating wearable technologies into existing healthcare systems presents logistical and operational challenges, including data-sharing inconsistencies and cybersecurity risks. Sustaining patient and clinician engagement over time remains critical, requiring strategies such as reinforcing the benefits of technology and optimizing alert systems to prevent fatigue.

This study has limitations, including a sample size that may restrict the generalizability of findings. Future research should involve larger, diverse cohorts to validate these results across different socio-economic and cultural contexts. Longitudinal studies are also needed to assess the sustainability of benefits and address barriers such as digital literacy and equitable access among older populations. Biases related to participant selection or familiarity with technology must also be considered. Additionally, more granular analyses, such as stratification by hypertension phenotypes, could enhance clinical relevance and guide tailored interventions.

Conclusions

Overall, this study underscores the potential of wearable device-based management strategies in improving hypertension outcomes among elderly patients. The integration of wearable technology into chronic disease management offers a promising approach to address the challenges of hypertension management, providing real-time monitoring, personalized interventions, and continuous patient support. These findings contribute valuable insights into the development of innovative hypertension management methods and highlight the need for further research to explore the long-term benefits and broader applications of such technologies. However, it is important to acknowledge certain limitations of this study. The relatively small sample size may affect the generalizability of the results, and the demographic constraints limit the applicability of the findings to more diverse populations. In addition, barriers to technology adoption, including digital literacy and financial limitations, should be addressed to ensure inclusivity and equity in future implementations. In conclusion, the use of wearable devices in the management of hypertension among elderly patients demonstrated significant improvements in blood pressure control, medication adherence, quality of life, knowledge of hypertension, and self-management efficacy. These results suggest that wearable technology, combined with chronic disease management platforms, can effectively address the challenges of managing hypertension in elderly populations, offering a critical tool for long-term disease management and improved health outcomes. Future studies should continue to explore the scalability and adaptability of such technologies in diverse patient populations and healthcare settings, while prioritizing the resolution of access disparities and the evaluation of long-term cost-effectiveness.

Consent for Publication

Written informed consent, permitting the publication of their clinical details, was obtained from the patients.

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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