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Wearable Devices for Elderly Health Management to Prevent Hypertension

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Abstract: Hypertension is the most common cardiovascular disease and an important risk factor for cardiovascular diseases such as coronary heart disease and heart failure. About 1/4 of the elderly worldwide suffer from hypertension. The number of hypertensive patients in China has reached 245 million, with approximately 1.7 million new cases occurring each year. This study was based on wearable devices and established a blood pressure health management platform for the elderly. By measuring indicators such as blood pressure, heart rate, and blood oxygen saturation, the health status of the elderly was monitored in real-time, and the risk factors for hypertension and their cognitive level of the disease were analyzed. The comparison of the management effects of wearable devices and conventional health management on elderly hypertension through randomized controlled trials showed that in terms of blood pressure control, the intervention group and the control group had an increase in systolic and diastolic blood pressure compared to baseline, with values of 1.45±13.74mmHg (intervention group) and 6.14±12.56mmHg (control group), respectively. The experimental results showed that wearable devices could control the diastolic and systolic blood pressure of patients to a certain extent in the hypertension management system, effectively monitor and warn the elderly of hypertension, and provide health management services to prevent hypertension for the elderly.

1. Introduction

Hypertension is a common cardiovascular disease, and its incidence is increasing year by year worldwide. Most patients are diagnosed in the middle and late stages, which not only causes physical pain to the patients themselves, but also brings huge economic burden to their families and society. It is estimated that the number of deaths caused by hypertension worldwide each year is as high as 12 million. Hypertension refers to systolic blood pressure (SBP) $\geq$ 140 mmHg and/or diastolic blood pressure (DBP) $\geq$ 90 mmHg. Severe hypertension can cause damage to target organs such as the heart, brain, and kidneys. According to research, there is a higher prevalence of hypertension among middle-aged and elderly people in China. Middle aged and elderly people are more prone to hypertension due to poor blood vessel elasticity, large blood pressure fluctuations, and various chronic diseases and psychological disorders. Currently, many studies have shown a significant increase in the incidence of hypertension with age. Therefore, early detection of hypertension is the key to effective prevention of hypertension. Wearable devices can monitor human health by collecting physiological information such as blood pressure, heart rate, blood oxygen, etc. This article aims to use wearable devices to monitor and warn the blood pressure of elderly people in real-time, improve their awareness and importance of their own health status, and provide scientific basis for effective prevention of hypertension.

2. Related Work

At present, research on wearable devices for elderly health management to prevent hypertension has attracted worldwide attention. These devices are designed to monitor the physiological indicators of the elderly, provide health data, and help them manage the risk of hypertension through reminders and feedback. In terms of research, some wearable devices such as smartwatches, smart bracelets, and blood pressure monitors conducted by Konstantinidis D have been applied to the management of hypertension in the elderly [1]. These devices can monitor blood pressure, heart rate, and exercise in real-time, and provide data analysis and health advice through mobile applications or cloud platforms. Some studies have also conducted related work on the management of hypertension in the elderly. For example, Bayoumy Karim was committed to developing smart wearable devices that connect to mobile applications through Bluetooth, providing personalized health management solutions for the elderly [2]. At the same time, Kishi Takuya conducted research on small wearable monitoring devices for remote blood pressure monitoring in the digital age of hypertension management [3].

Overall, research on wearable devices for preventing hypertension in elderly health management is constantly evolving. The emergence of these devices has provided more convenient and personalized health management methods for the elderly, and is expected to play a positive role in hypertension management for the elderly in the future. However, there are still many shortcomings in wearable devices for elderly health management in preventing hypertension. Therefore, this article conducted corresponding research and exploration on this issue.

3. Characteristics of Hypertension in the Elderly

According to the 2019 Global Blood Pressure Survey Report released by the WHO, China is the world's largest country with the highest incidence and burden of hypertension. About 1/4 of the world's elderly suffer from hypertension, and the prevalence of hypertension among middle-aged and elderly people in China is 29.6%. The Chinese Guidelines for the Prevention and Treatment of Hypertension point out that among the population aged 40 and above in China, 1 in 3 people suffers from hypertension. Among the population aged 65 and above, one in every five people suffers from hypertension; one out of every five elderly people suffers from hypertension [4].

With the intensification of China's aging population, the incidence of hypertension in the elderly population is rapidly increasing, and the incidence of hypertension in the elderly is also increasing year by year. As elderly people age, arterial elasticity and vascular compliance decrease, vascular resistance increases, and blood pressure levels continue to rise [5]. Due to reasons such as lack of exercise and reduced physical activity in the elderly, blood pressure is prone to increase under conditions such as fatigue, emotional excitement, and lack of sleep. When the elderly have chronic diseases such as diabetes, hyperlipidemia and arteriosclerosis, their blood pressure is also more likely to rise [6]. Therefore, this study combines wearable devices and internet platform technology to monitor and warn the health status of the elderly in real-time, and combines data analysis results with doctor feedback information to form a comprehensive health management platform [7].

3.1 Lifestyle Aspect

There are many risk factors for elderly people suffering from hypertension, but they can be summarized into the following aspects. The first is unreasonable diet: most hypertensive patients have obesity, which is the main risk factor for hypertension. The second is bad lifestyle habits: elderly people are prone to contracting various diseases due to decreased physical function and resistance, which can lead to a series of pathological changes in the body, resulting in a series of bad lifestyle habits. Lack of sleep, prolonged mental stress, smoking and alcohol abuse can all lead to elevated blood pressure. The third is excessive drinking: excessive drinking increases the risk of hypertension and cardiovascular disease. A study has found that when drinking heavily, the blood pressure of hypertensive patients increases by an average of 10-15 mmHg compared to the normal population. Therefore, elderly people should avoid excessive drinking in their daily lives. If they want to drink alcohol, they should also control their alcohol consumption and try to reduce drinking on an empty stomach in the morning. The fourth is excessive smoking: smokers have a 2-4 times higher risk of developing hypertension than non-smokers, and quitting smoking can effectively reduce the risk of developing hypertension [8].

3.2 Aspect of Drug Treatment

Hypertension is a common cardiovascular disease, and currently there is no medication that can control blood pressure. Patients need to take medication for life, which increases their economic and psychological burden for the elderly. Therefore, how to reduce the cost of medication for patients is an urgent problem that needs to be solved in clinical practice [9].

In recent years, with the rapid development of big data and artificial intelligence technology, more and more people have begun to pay attention to the application of wearable devices for elderly blood pressure monitoring and health management. In 2014, China's first "Guidelines for the Prevention and Treatment of Hypertension in China" pointed out that comprehensive treatment strategies should be adopted for hypertension in the elderly. In terms of drug treatment, the guidelines recommend the use of multiple antihypertensive drugs such as ARB (Angiotensin Receptor Blocker), CCB (Calcium Channel Blockers), and diuretics in combination. For elderly hypertensive patients with diabetes, chronic kidney disease and chronic obstructive pulmonary disease (COPD), priority should be given to ACEI (Angiotension Converting Enzyme Inhibitors) or ARB antihypertensive drugs [10]. Meanwhile, attention should be paid to protecting target organs during treatment. Target organ protection includes reducing the risk of myocardial infarction, heart failure, stroke, kidney injury and atherosclerosis. Therefore, lifestyle intervention measures should also be actively taken in addition to medication treatment. In addition to lifestyle interventions, non-pharmacological treatment methods should also be used to control blood pressure and assess cardiovascular risk in hypertensive patients, in order to further develop personalized treatment plans [11].

3.3 Aspect of Wearable Devices

Wearable devices refer to electronic devices with wearability, spontaneity, and ease of operation. According to different application fields, wearable devices can be divided into smartwatches, smart bracelets, smart glasses, sports bracelets, and wearable blood pressure monitors. This study chooses smartwatches as the main monitoring object and collaborates with hospitals to connect the hospital's blood pressure monitoring results with wearable devices in real-time for data collection and analysis.

Smart bracelets have become an important tool for elderly people to prevent hypertension due to their simple and convenient wearing, accurate and reliable measurement results, and other characteristics. At present, the smart bracelet products on the market are mainly divided into three types: sports watches, sleep bracelets, and blood pressure monitors. Among them, the sports bracelet is mainly used to measure heart rate; sleep watches are mainly used to measure sleep time; a blood pressure monitor measures blood pressure by connecting it to a blood pressure monitor. The study focuses on smart bracelets as the main monitoring object, and selects multifunctional wearable bracelets as monitoring devices based on the characteristics of hypertension prone populations, combined with blood pressure data provided by hospitals for real-time monitoring [12].

4. Construction of Blood Pressure Management Platform

In the context of "Internet plus+Medical", the "Healthy China" strategy provides an effective information sharing platform for all sectors of society and the public. From the current development status of China's society and healthcare system, there are still significant difficulties in data sharing among hospitals, governments, and various sectors of society [13]. In this context, the elderly blood pressure health management platform based on wearable devices can achieve data sharing between different institutions and departments through the data sharing platform, so that the data information of each institution can be uniformly managed, utilized, and integrated. The framework diagram shown in Figure 1 is constructed.

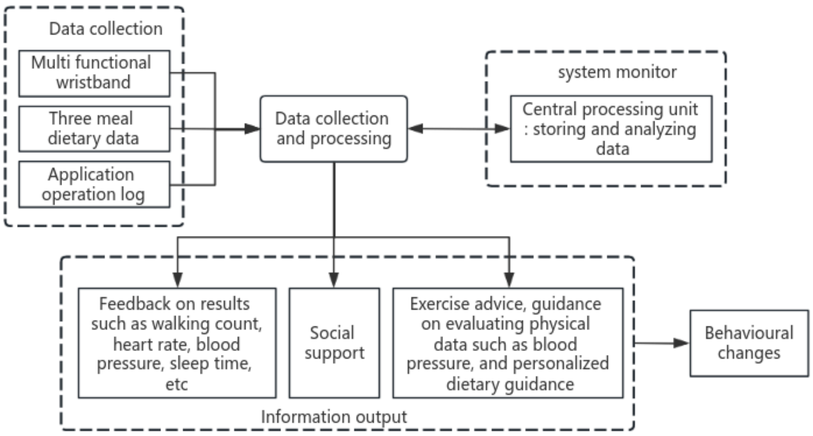

Figure 1: Wearable device monitoring and management framework for hypertension

Among them, data collection mainly focuses on multifunctional bracelets to provide basic data information for experimental testing, various physical indicators of hypertension patients, and life improvement. Through data collection and processing, various data indicators of the tested individuals are analyzed and processed, and suggestions on aspects such as life, society, and exercise are given, thereby changing the patient's behavior.

This research uses the Internet plus medical model to build a blood pressure health management platform for the elderly. This platform integrates different medical resources such as hospitals and families, and achieves cross regional and cross institutional medical information sharing through Internet technology. Firstly, wearable devices are connected to mobile apps so that patients can monitor their blood pressure while seeking medical attention in the hospital. Secondly, the collected blood pressure data is transmitted to the hospital for analysis and management [14]. Finally, patients can self measure their blood pressure at home through wearable devices and monitor their own health status in a timely manner, as shown in Figures 2, 3, and 4, which are the recorded data of a certain wearable device.

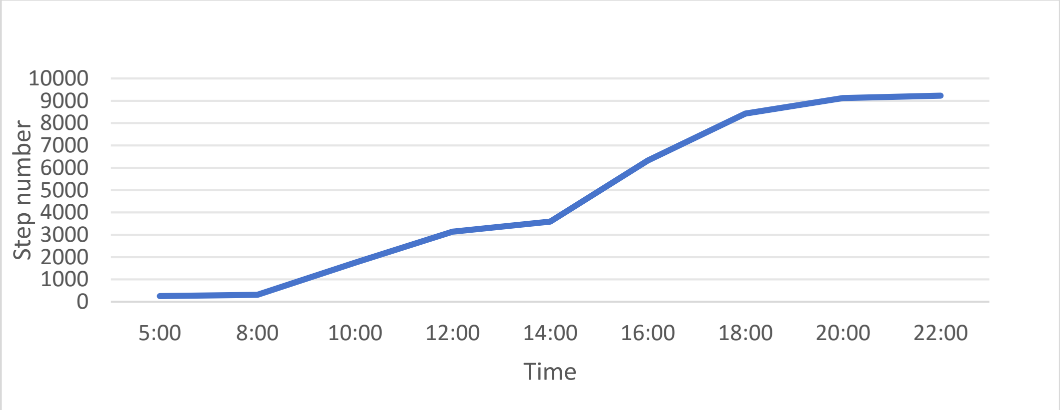

Figure 2: Wearable device walk count record

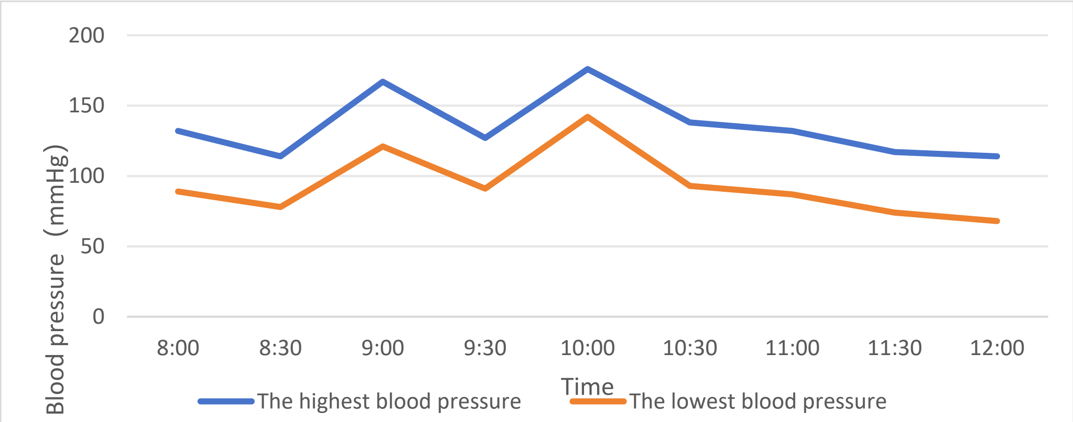

Figure 3: Wearable device blood pressure measurement record

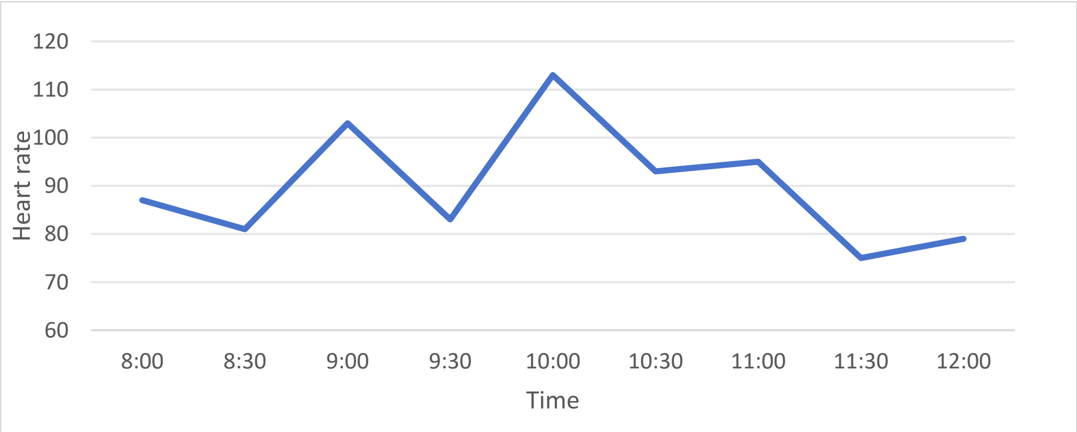

Figure 4: Wearable device heart rate measurement record

Through the information sharing platform between wearable devices and different medical resources such as hospitals, homes, and communities, data sharing between different institutions and departments can be uniformly managed, utilized, and integrated. Afterwards, the patient self tests their blood pressure through wearable devices and uploads it to the platform. When the patient's blood pressure or blood oxygen saturation falls below the set threshold, the platform would automatically alarm and push relevant personnel for remote management. At the same time, wearable devices provide remote guidance from doctors for patient follow-up and follow-up [15]. The health management platform can achieve real-time monitoring and early warning of the health status of the elderly by sharing data with departments such as the Ministry of Health and the National Medical Products Administration, providing health management services to prevent hypertension for the elderly [16].

5. Experimental Results

This article evaluates the effectiveness of hypertension prevention and management through a 6-month wearable device study through comparative analysis. It is proposed to use a completely randomized design with the same sample mean as a comparative statistical method. According to Formulas 1 and 2, the sample size for this study is estimated:

$$\text{Unilateral:}\ \ n_1 = n_2 = 2[\frac{(t_{2\alpha} + t_{2\beta})^2 s}{\delta}]^2 \tag{1}$$

$$\text{Bilateral:}\ \ n_1 = n_2 = 2[\frac{(t_{\alpha} + t_{\beta})^2 s}{\delta}]^2 \tag{2}$$

In the formulas, n_1 and n_2 are two experimental observation groups with the same number of people, with values of 0.05 for α , 0.2 for β , and 5 for s. Due to the long duration of the trial, patients may not be able to persist for a long time, resulting in non-compliance. Therefore, the correction formula is used, as shown in Formula 3:

$$n_i = \frac{n}{(1-P_m)^2} \tag{3}$$

In the formula, n_i represents different groups, and P_m represents the proportion of uncertain population to the total population. The total sample size for the study is 320 people, with 160 people in each of the control group and intervention group.

Among all the research subjects, 95.625% are able to follow medical advice and take antihypertensive drugs on a scheduled basis, and 90% are able to adhere to medication adherence. The monitoring frequency through wearable devices (multifunctional smart bracelets) is 83.125%, 13.125%, and 3.75% daily, weekly, monthly, or less, respectively. The specific monitoring status is shown in Table 1.

Table 1: Health behavior testing status of wearable devices within six months

Behavior	Intervention group(n=160)	Control group(n=160)	P value
Whether to take medication according to medical advice, n (%)	154(96.250%)	152(95.000%)	0.505
Difficult	4(2.597%)	3(1.974%)	0.916
Sometimes	5(3.247%)	6(3.947%)	
Persist in taking medication	145(94.156%)	143(94.08%)	
Self monitoring frequency, n (%)	160(100%)	160(100%)	
Every day	135(84.375%)	131(81.875%)	0.325
Every week	19(11.875%)	23(14.375%)	
Monthly or less	6(3.750%)	6(3.750%)	

Moreover, during the 6-month monitoring, it is found that the intervention group has a

1.45±13.74mmHg increase in diastolic blood pressure and a 0.43±3.14kg increase in weight, while the control group has a 6.14±12.56mmHg increase in diastolic blood pressure and a 3.83±2.53kg increase in weight. The intervention group has a better and more significant effect on diastolic blood pressure and weight compared to the control group, and the difference is statistically significant (P<0.05). There is no significant difference in other physical measurement indicators between the two groups, as shown in Table 2.

Table 2: Changes in body measurement data between two groups within six months

Index	Intervention group(n=160)	Control group(n=160)	P value
Differential systolic blood pressure (mmHg)	4.12±12.15	6.51±18.35	0.361
Diastolic blood pressure difference (mmHg)	1.45±13.74	6.14±12.56	0.054
Weight difference (kg)	0.43±3.14	3.83±2.53	0.049
Body mass index difference	0.71±3.12	0.59±1.84	0.892
Difference in body fat content (%)	0.79±4.52	0.89±5.43	0.859
Difference in basal metabolism of the body (kcal)	8.12±162.35	4.64±62.89	0.962

From Table 2, it can be seen that there is no significant difference between the two groups in BMI (Body Mass Index), body fat content, and basal metabolism, except for systolic and diastolic blood pressure and weight difference. The results of this randomized controlled trial comparing the management effects of wearable devices and conventional health management on elderly hypertension show that in terms of blood pressure control, the intervention group and the control group have an increase in systolic and diastolic blood pressure compared to baseline, but the intervention group has less increase in diastolic blood pressure compared to the control group. The intervention group shows a lower increase in blood pressure compared to the contraction group, and it is also lower than the control group. The experimental results indicate that wearable devices can to some extent control the diastolic and systolic blood pressure of patients in the hypertension management system.

In the experiment, the collected blood pressure data is transmitted to the server through wireless communication protocol and processed and analyzed on the server. Electrocardiogram and blood pressure signals are used as signal sources to measure heart rate and blood pressure. Bluetooth communication protocol is utilized to achieve wireless connection and obtain measurement results. After obtaining heart rate and blood pressure data, the collected heart rate and blood pressure data are fitted.

By comparing the heart rate measured by wearable devices with the actual value, the results show that the wearable device measurement results are basically consistent with the actual value. Meanwhile, wearable devices have the advantages of convenient measurement, reliable data, and strong mobility. Meanwhile, through the analysis of blood pressure values, it is found that there is a certain correlation between heart rate and blood pressure, indicating that using wearable devices to monitor heart rate and blood pressure values is feasible. Therefore, based on this model, the health status of the elderly can be effectively predicted.

The experimental results show that the system can obtain real-time human electrocardiogram data and blood pressure data, and analyze and process the data, thereby helping people better understand their physical condition and take corresponding measures to prevent diseases. The application of this system would provide more convenient, accurate, and timely health management services for the elderly.

6. Conclusions

By using wearable devices to monitor blood pressure in the elderly, real-time monitoring and early warning of their health status can be achieved, which is beneficial for timely detection and intervention in the occurrence and development of hypertension. According to the different living habits and physiological characteristics of the elderly, their blood pressure at different time periods can be monitored, and hypertension patients at different ages can be effectively warned and intervened, so as to reduce the incidence rate of hypertension. Wearable device technology, information and communication technology, mobile communication devices and other technologies are utilized, and more scientific dietary and exercise management solutions are used. Offline health knowledge lectures are combined, and a wearable device mobile medical detection system that integrates social doctors and nutritionists has a certain effect on the management of elderly hypertension. However, at present, the functions of wearable devices are still relatively limited, only providing basic information such as blood pressure and heart rate. Therefore, it is necessary to further improve the functionality of wearable devices to better serve the elderly.

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