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Analysis of the Effectiveness and User Acceptance of Smart Wearable Devices in the Management of Chronic Diseases in the Elderly

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Abstract: *Objective*: To explore the application effect of smart wearable devices in the management of elderly chronic diseases and their user acceptance, with a view to providing new technical support for the health management of elderly patients with chronic diseases. *Methods*: In this study, a randomized crossover controlled trial design was adopted, and 500 elderly chronic disease patients in Xi'an City were selected as the study subjects during the period from January 2023 to January 2024, and the study subjects were randomly divided into 250 each in the control group and the observation group. The study was divided into two phases of 8 weeks each, with a 4-week washout period in the middle. In the first phase, the control group used traditional health monitoring methods and the observation group used smartwatches with physiological monitoring functions for daily health data monitoring; in the second phase, the two groups switched roles, i.e., the control group used smart wearable devices and the observation group returned to traditional monitoring methods. Through questionnaires, interviews, and physiological data collection, the application effect and user acceptance of smart wearable devices were evaluated. The study data included patients' physiological indicators such as heart rate, blood pressure, and sleep quality, as well as patients' satisfaction, frequency of use, and adherence to smart wearable devices. *Results*: In the first stage, patients in the observation group who used smartwatches had significantly higher accuracy in heart rate, blood pressure, blood glucose, and sleep quality monitoring than those in the control group ($P < 0.05$). The observation group's satisfaction score (out of 5) with the smartwatch was significantly higher than the control group's ($P < 0.05$). The frequency of smart wearable device use and adherence were also significantly higher in the observation group than in the control group ($P < 0.05$). After the second phase of role-swapping, the original control group showed improved monitoring accuracy and adherence during the smart device use phase, whereas the original observation group showed a decrease in these indicators after returning to traditional monitoring methods, but user satisfaction and adherence remained higher than they had been in the first phase. *Conclusion*: Smart wearable devices have significant application effects in the management of chronic diseases in the elderly, can effectively improve patients' health management compliance and satisfaction, and have a high degree of user acceptance. Therefore, smart wearable devices are expected to become an important tool for the health management of elderly chronic disease patients.

Keywords: Smart wearable devices; Elderly; Chronic diseases; Health management; User acceptance

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1. Introduction

Chronic disease is a kind of disease that mostly occurs in the elderly population, including coronary heart disease, hypertension, diabetes, and so on. If timely and effective intervention cannot be given, with the continuous progress of the disease and the acute attack, it may lead to the inability of the elderly patients to seek help in time, and then irreversible and serious consequences will occur [1–3]. At present, the prevalence of chronic diseases among the elderly in China is high, and the phenomenon of coexistence of multiple diseases is common [4]. Chronic diseases have become a major problem affecting the health of the elderly population, and they have many adverse effects on the normal life of the elderly. Data from the seventh population census show that the proportion of older persons over 60 years of age in China is 18.7 percent [5]. Studies show that the elderly population suffering from chronic diseases in China is as high as 150 million, accounting for 65% of the total number of elderly people [6]. The traditional chronic disease management model is constrained by space and time, which makes it impossible to carry out chronic disease management in a timely, continuous, and effective manner, and the chronic disease control rate has been low. The traditional chronic disease management model has made it difficult to meet the needs of modern society. As an emerging health monitoring tool, smart wearable devices, with their portability and real-time monitoring function, provide new possibilities for chronic disease management in the elderly [7]. Several studies have shown that the application of smart wearable devices in the health management of patients with chronic diseases is feasible. Wearable smart devices in the field of chronic diseases are mainly applied in the field of health management, including individual health data monitoring, health risk prediction and early warning, health promotion and health education, etc. [8–9]. Based on this, this paper aims to explore the application effect and user acceptance of smart wearable devices in chronic disease management in the elderly through empirical research.

2. Information and methodology

2.1. General information

Between January 2023 and January 2024, 500 cases of elderly patients with chronic diseases in Xi'an were selected as the study subjects, and they were divided into the control group and the observation group according to the method of random number table, with 250 cases in each group. In the control group, there were 130 males and 120 females; the average age was (68.5 ± 5.2) years old; and the types of chronic diseases were: 80 cases of hypertension, 60 cases of diabetes mellitus, 50 cases of coronary heart disease, 30 cases of chronic obstructive pulmonary disease, and 30 cases of other chronic diseases. In the observation group, there were 125 males and 125 females; the average age was (69.2 ± 4.8) years; the types of chronic diseases: 75 cases of hypertension, 55 cases of diabetes mellitus, 45 cases of coronary heart disease, 25 cases of chronic obstructive pulmonary disease, and 50 cases of other chronic diseases. The general information of the two groups of patients was comparable with no statistically significant difference ($P > 0.05$). The study was reviewed and approved by the Medical Ethics Committee of the hospital; all study subjects and their families or guardians signed an informed consent form on the premise of understanding the content of the study.

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Aged 60 and above to ensure that the study population is an elderly group; (2) At least one chronic disease diagnosed and under treatment, such as hypertension, type 2 diabetes mellitus, coronary heart disease, chronic obstructive pulmonary disease, etc.; (3) Able to complete the questionnaire independently.

Exclusion criteria: (1) Severe visual or hearing impairment, which affects the completion of the questionnaire

or the use of the equipment; (2) People with a combination of mental illness or cognitive impairment; (3) Unstable health condition, recent (e.g., within the past 3 months) serious cardiac, hepatic, or renal dysfunction, or other serious illnesses that may affect the results of the study.

2.3. Methodology

The study was divided into two phases of 8 weeks each, with a 4-week washout period in between (the washout period was designed to remove the effects of the previous phase of the intervention and ensure the accuracy of the second phase of the assessment).

Phase 1: The control group used traditional health monitoring methods, which included the following aspects. Heart rate (HR) and blood pressure monitoring: HR and blood pressure were monitored using an Omron HEM-907XL sphygmomanometer, which was measured by the subjects themselves on a daily or weekly basis, including HR, systolic blood pressure (SBP) and diastolic blood pressure (SBP) and diastolic blood pressure (DBP). Measurements were made in a quiet state and following the instructions for the use of the sphygmomanometer. Each measurement was taken 3 times and the average value was taken. Blood glucose monitoring. Participants were required to use the Roche Accu-Chek Performa blood glucose meter to monitor blood glucose regularly (e.g., daily or weekly) according to the doctor's instructions or personal needs, and to record fasting plasma glucose (FPG) and 2 h postprandial plasma glucose (2 h postprandial glucose (2hPG)) values. The Pittsburgh Sleep Quality Index (PSQI) was used to assess the sleep quality of the subjects, which consisted of 19 self-assessed items and 5 other-assessed items, of which the 19th self-assessed item and 5 other-assessed items were not involved in the scoring, and the 18 self-assessed items involved in the scoring consisted of 7 scoring factors, which were: sleep quality, time to sleep, sleep duration, sleep efficiency, sleep disorders, hypnotic drugs, and daytime functioning. Each factor has 0–3 points, and the sum of the 7 factor scores is the total PSOI score (0–21 points). A total score of >8 points suggests poor sleep quality, and the higher the score, the worse the sleep quality [10]. Hospital physical examination: Regular (e.g., quarterly or half-yearly) health checkups. Physical examination items include blood pressure, heart rate, blood glucose, blood lipids, electrocardiogram, and so on. Physical examination reports need to be interpreted by a professional doctor and the indicators recorded. Paper-based health logs: Paper-based health logs will be used to record the patients' own daily health status, including self-perception, medication intake, and living habits. The researcher will collect these logs regularly to assess the participants' adherence to health management. Regular follow-up: During the study period, the researcher will conduct face-to-face or telephone follow-up visits to the control group once a month to understand the use of traditional health monitoring methods, collect participants' feedback, as well as provide necessary health guidance.

The observation group will use smartwatches with physiological monitoring functions for daily health data monitoring, as described in the protocol below. The observation group will select and purchase smartwatches on their own, and the researcher will provide a recommended list of reputable and fully functional smartwatches on the market to ensure the basic monitoring functions and data accuracy of the devices. The researcher will assist the participants in understanding the features and prices of different devices so that they can choose according to their situation. (1) Smartwatch selection: the researcher will provide a recommended list of at least three smartwatches that meet the study needs, have physiological indicator monitoring functions such as blood pressure monitoring, blood glucose monitoring, heart rate monitoring, sleep quality analysis, etc., and can synchronize data to the user's mobile phone app via a wireless network. (2) Device selection guidance: The researcher will organize a device selection guidance meeting to introduce the smartwatches on the recommended list to the observation group and

provide advice and guidance on device selection. (3) Daily monitoring: The observation group will purchase the smartwatch by themselves before the study starts and follow the researcher's instructions for setting and daily use. The researcher will provide a detailed manual and online support to ensure that each participant can operate the device proficiently. (4) Data synchronization and analysis: Participants' smartwatch data will be synchronized to the cloud server via the app, and the data will be analyzed by professional software to generate health reports. The researcher will check the data synchronization regularly to ensure the accuracy and completeness of the data. (5) Regular follow-up: During the study period, the researcher will conduct face-to-face or telephone follow-up visits to the participants in the observation group once a month to learn about the use of the device, collect user feedback, and solve the problems encountered in the process of use.

Phase 2: The control and observation groups swapped monitoring methods. Between the two intervention phases, participants will enter a 4-week washout period. During this period, all participants will suspend the use of any health monitoring tools and maintain routine medical care. The research team will monitor participants' health to ensure that each study participant's health is in a stable state in preparation for the next phase of the intervention. At the end of each intervention phase and the end of the washout period, follow-up visits will be conducted either face-to-face or by phone to collect data on physiological indicators, user satisfaction, and adherence.

2.4. Observation indicators and evaluation criteria

Physiological monitoring indicators. The difference in accuracy between the smartwatch and traditional monitoring methods was assessed by comparing it with the results of the physical examination in the hospital. The normal value of HR was 60– 100 beats/min, the normal value of FPG was 4.1–5.9 mmol/L, the normal value of 2hPG was ≤7.8 mmol/L and the normal value of hypertension was specifically referred to the "Guidelines for the Prevention and Control of High Blood Pressure in China (Revised Edition 2024)" [11].

User satisfaction. The questionnaire was used to collect users' satisfaction with smart wearable devices, including five dimensions of device ease of use, data accuracy, timely information feedback, comfort, and battery life, with each dimension using a 5-point scale, and the higher the score, the higher the satisfaction. The Cronbach's α coefficient of this questionnaire is 0.987, with good reliability and validity.

Device usage frequency. Record the frequency of use of the smartwatch, including the daily wearing time, the number of times the monitoring function is used, and so on.

Adherence. The adherence of the two groups of patients was assessed in three aspects: medication, lifestyle modification, and regular monitoring.

2.5. Statistical methods

SPSS 25.0 statistical software was used to process the data, and the measurement information was expressed by Mean ± SD. The comparison between the two groups was made by independent samples *t*-test, and the counting information was expressed by n/%. The comparison between the groups was made by $x2$ test, and the difference was considered to be statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of physiological monitoring indices in Stage I and II between the two groups of patients

In stages 1 and 2, the HR, SBP, DBP, FPG, and 2hPG of the two groups were compared, and the difference was

not statistically significant ($P > 0.05$); in stages 1 and 2, the total PSQI score of the observation group was lower than that of the control group, and the difference was statistically significant ($P < 0.05$); in stage 2, the total PSQI score of the two groups was lower than that of the control group, and the difference was statistically significant ($P < 0.05$) (**Table 1**).

Table 1. Comparison of physiological monitoring indices between the two groups of patients in stages I and II ($n = 250$, Mean ± SD)

Groups	Times	HR (cycles/min)	SBP (mmHg)	DBP (mmHg)	FPG (mmol/L)	2hPG (mmol/L)	Total PSQI score (points)
Control subjects	Stage I	77.0 ± 6.5	140.5 ± 15.0	85.0 ± 9.0	6.8 ± 1.2	10.1 ± 2.0	11.0 ± 3.5
Observation group	Stage I	76.5 ± 6.0	139.0 ± 14.5	84.5 ± 8.5	6.7 ± 1.1	9.9 ± 1.8	9.5 ± 3.0
t		0.894	1.137	0.639	0.971	1.175	5.145
P		0.372	0.256	0.523	0.322	0.241	0.000
Control subjects	Stage II	77.0 ± 6.0	139.0 ± 14.0	84.0 ± 8.5	6.7 ± 1.3	10.1 ± 2.1	10.0 ± 3.2*
Observation group	Stage II	76.8 ± 5.8	138.5 ± 13.8	83.8 ± 8.2	6.8 ± 1.0	9.9 ± 1.7	8.8 ± 2.8*
t		0.379	0.402	0.267	0.964	1.170	4.462
P		0.705	0.688	0.789	0.336	0.242	0.000

Note: *$P < 0.05$ compared to cohort stage I

3.2. Comparison of User Satisfaction Scores for Stages 1 and 2 in the two groups of patients

In stages I and II, the device ease of use, data accuracy, information feedback timeliness, comfort, and battery life scores of the observation group were higher than those of the control group, and the difference was statistically significant ($P < 0.05$); in stage II, the device ease of use, data accuracy, information feedback timeliness, comfort, and battery life scores of both groups were higher than those of the control group, and the difference was statistically significant ($P < 0.05$) (**Table 2**).

Table 2. Comparison of user satisfaction scores at stages 1 and 2 in both groups ($n = 250$, Mean ± SD)

Groups	Times	Device ease of use	Data accuracy	Timeliness of information feedback	Comfort	Battery Life
Control subjects	Stage I	3.2 ± 0.6	3.1 ± 0.5	3.0 ± 0.5	2.9 ± 0.5	2.8 ± 0.5
Observation group	Stage I	4.2 ± 0.5	4.3 ± 0.4	4.1 ± 0.4	4.1 ± 0.4	4.0 ± 0.4
t		4.882	29.632	24.693	29.632	29.632
P		0.000	0.000	0.000	0.000	0.000
Control subjects	Stage II	4.0 ± 0.5*	3.9 ± 0.4*	3.8 ± 0.4*	3.9 ± 0.4*	3.7 ± 0.4*
Observation group	Stage II	4.1 ± 0.5*	4.2 ± 0.4*	4.0 ± 0.4*	4.0 ± 0.4*	3.9 ± 0.4*
t		2.236	8.385	5.590	2.795	5.590
P		0.026	0.000	0.000	0.005	0.000

Note: *$P < 0.05$ compared to cohort stage I

3.3. Comparison of the frequency of device use in Stages 1 and 2 in the two groups of patients

In stage 1, the daily wearing time of the observation group was longer than that of the control group, and the number of times the monitoring function was used was higher than that of the control group, with statistically significant differences ($P < 0.05$); in stage 2, the daily wearing time of the observation group was shorter than that of the control group, and the number of times the monitoring function was used was lower than that of the control group, with statistically significant differences ($P < 0.05$); in stages 1 and 2, the daily wearing time and number of times the monitoring function was used in both groups were statistically significant ($P < 0.05$). Use times were compared, and the difference was statistically significant ($P < 0.05$) (**Table 3**).

Table 3. Comparison of frequency of device use in Stage I and II between the two groups of patients ($n = 250$, Mean ± SD)

Groups	Times	Daily wearing time (h)	Number of monitoring function uses (times)
Control subjects	Stage I	5.4 ± 1.2	4.7 ± 2.9
Observation group	Stage I	7.5 ± 1.1	9.3 ± 3.1
t		20.400	17.134
P		0.000	0.000
Control subjects	Stage 2	7.4 ± 2.1*	8.9 ± 3.7*
Observation group	Stage 2	6.5 ± 2.2*	7.3 ± 3.5*
t		4.679	4.967
P		0.000	0.000

Note: *$P < 0.05$ compared to cohort stage I

3.4. Comparison of adherence between the two groups of patients in stages one and two

In stage I, the medication, lifestyle adjustment, and regular monitoring adherence of the observation group was higher than that of the control group, and the difference was statistically significant ($P < 0.05$); in stage II, the comparison of medication, lifestyle adjustment, and regular monitoring adherence between the two groups was not statistically significant ($P > 0.05$); in stage II, the compliance of the control group was higher than that of stage I and the difference was statistically significant ($P < 0.05$) (**Table 4**).

Table 4. Comparison of adherence between the two groups of patients in stages I and II ($n = 250$, n/%)

Groups	Times	Medication	Lifestyle adjustments	Regular monitoring
Control subjects	Stage I	150/60.0	150/60.0	140/56.0
Observation group	Stage I	205/82.0	200/80.0	190/76.0
x^2		29.383	23.810	22.282
P		0.000	0.000	0.000
Control subjects	Stage II	200/80.0*	185/74.0*	175/70.0*
Observation group	Stage II	205/82.0	195/78.0	180/72.0*
x^2		0.325	1.096	0.243
P		0.569	0.295	0.622

Note: *$P < 0.05$ compared to cohort stage I

4. Discussion

This study provides insights into the effectiveness of smart wearable devices and their user acceptance in the management of chronic diseases in the elderly through a randomized crossover controlled trial. The results of the study showed that smart wearable devices have significant advantages in terms of physiological monitoring accuracy, user satisfaction, frequency of use, and adherence.

4.1. Advantages of smart wearable devices in terms of physiological monitoring accuracy

Smart wearable devices monitor key physiological parameters in real time through high-precision sensors, and their monitoring results are basically the same as those of traditional monitoring methods, and they are more convenient and time-saving than traditional monitoring means. This is mainly due to the high sensitivity and real-time nature of smart devices, which can detect physiological changes in patients promptly and provide more accurate data support for chronic disease management. In addition, the portability of smart devices allows patients to conduct self-monitoring anytime and anywhere, reducing the possibility of missing monitoring due to time and location constraints, thus improving the continuity and completeness of monitoring.

4.2. Smart wearable devices can improve user satisfaction

User satisfaction is one of the important indicators of the application effect of smart wearable devices. The results of this study show that the observation group's satisfaction scores for smart wearable devices were significantly higher than those of the control group, and the difference was statistically significant ($P < 0.05$), which may be related to a variety of factors, such as the ease of use, data accuracy, timeliness of information feedback, comfort, and battery life of smart wearable devices. Smart devices usually have intuitive user interfaces and simplified operation processes, making it easy for elderly users to get started. At the same time, smart devices can provide real-time feedback on monitoring data, allowing users to keep abreast of their health status, immediacy, and interactivity not found in traditional monitoring methods.

4.3. Smart wearable devices can improve the frequency of device use and adherence

The frequency of use and adherence of smart wearable devices are also important indicators for assessing the effectiveness of their application. The results of this study showed that the frequency of use and adherence during the use of smart wearable devices in the observation group were significantly higher than those in the control group, and the difference was statistically significant ($P < 0.05$), which suggests that smart wearable devices can stimulate the initiative and participation of elderly patients with chronic illnesses in their health management, thus improving their adherence to medical advice and health recommendations. The reminder and motivation functions of smart devices may play an important role in this process, helping patients form good health monitoring habits through regular reminders and health goal setting.

4.4. Prospects of smart wearable devices in chronic disease management for the elderly

With the continuous progress of technology and the increasing improvement of functions, the application of smart wearable devices in the management of chronic diseases in the elderly has a broad prospect. Firstly, smart devices can serve as a powerful supplement to traditional medical resources, providing more convenient and personalized health management services for elderly chronic disease patients. Secondly, the data collection and analysis capabilities of smart devices offer the possibility of early intervention and precise treatment of chronic diseases. In addition, smart devices can be combined with telemedicine services to achieve remote monitoring and immediate

intervention for elderly patients with chronic diseases, improving the coverage and efficiency of medical services.

4.5. Limitations of the study and future research directions

Despite the desirable results of this study, there are some limitations. First, the study sample size was limited and restricted to elderly patients with chronic diseases in Xi'an, which may limit the general applicability of the results. Future studies may consider expanding the sample size to cover a wider range of regions and populations. Second, the follow-up time of this study was short, and the effect of long-term application of smart wearable devices and user acceptance needs to be further observed. In addition, data security and privacy protection of smart wearable devices are also important issues that need to be focused on in future studies. Future studies can further explore the effectiveness of smart wearable devices in the management of different chronic diseases and how to optimize the device functions and user interface to better meet the needs of elderly chronic disease patients.

In summary, smart wearable devices have demonstrated significant application effects and high user acceptance in geriatric chronic disease management, and are expected to become an important tool for improving the quality of health management for elderly chronic disease patients. Future research and practice should continue to explore the optimization and application of smart wearable devices to achieve the innovative development of chronic disease management in the elderly.

Disclosure statement

The authors declare no conflict of interest.

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