Prevention of Cardiovascular and Cerebrovascular Diseases in the Elderly based on Smart Senior Care Healthy Monitoring

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Abstract. With the deepening of social aging and the high mortality rate of cardiovascular and cerebrovascular diseases in China, a smart senior care health monitoring model is adopted to monitor the health of the elderly in real-time, to achieve the effect of preventing cardiovascular and cerebrovascular diseases in the elderly. The study sample consisted of a key community monitoring population in Xintang Town, Zengcheng District, Guangzhou who participated in at least two annual medical examinations under the National Basic Public Health Service Program between January 2020 and July 2021. The study includes two sets of controlled trials, and statistical analysis is conducted using two independent samples t-tests, Mann-Whitney U-test, Pearson chi-square test or Fisher's exact probability method, paired t-test, analysis of covariance, and multifactor linear regression model. A smart health-based monitoring approach for elderly individuals was connected with a decrease in systolic blood pressure (P=0.000). Smart senior care health monitoring aids in the prevention of cardiovascular disease in the elderly.

Keywords: Smart senior care, cardiovascular disease, blood pressure, prevention.

1. Introduction

Since the British Life Trust formally proposed the concept of "smart aging" in 2012, the research and application of smart aging has been rapidly developed. For the first time in China, Zuo proposed the concept of "smart aging," which involves the application of information technology and other forms of cutting-edge science and technology to the care of the elderly, with the goal of enhancing their quality of life and maximizing their dignity and worth by tapping into their accumulated knowledge and experience [1].

According to figures from the seventh population census, China's elderly population reached 190 million by the end of 2020, or 13.5% of the overall population. China's population has already entered the aging phase by international standards. In the 14th five-year plan of national economic and social development and the outline of 2035 visionary goals, it is proposed to "implement the national strategy of actively coping with population aging," which for the first time elevates actively coping with population aging to a national strategy, and to use new generation information technology to cultivate new business models of smart aging, develop the smart aging industry, and assist China's aging career development [2].

At present, the active exploration on the issue of smart elderly care in the academic field is mainly focused on three aspects. Based on the many challenges and opportunities facing China's home care service, Sui proposed the construction of "Internet + home care" as a smart home care service model [3]. Huang et al. discussed the strategy of constructing a new model of "Internet+ community+ medical" home wisdom elderly care under the new coronavirus pneumonia epidemics, and made suggestions to accelerate the development of wisdom elderly care [4]. The second is the exploration of wisdom elderly practice. Chang takes Hangzhou's innovative practice as a sample, compares the current situation of the development of wisdom elderly at home, and proposes the construction of wisdom elderly at home service system from the perspective of holistic governance [5]. Wu et al. suggest the concept of "two-way empowerment" based on the case of wisdom elderly care practice in J district of Nanjing, and believe that the problem of digital capability gap among elderly people hinders the further promotion of wisdom elderly care, and then put forward the concept of "two-way empowerment" to stimulate the potential of supply and demand through modern enabling technology

[6]. Thirdly, the discussion on the construction of technology and service platform for wisdom elderly care, Guo discusses the connotation and characteristics of wisdom elderly care platform, and proposes to build a wisdom platform based on business-oriented operation, superior knowledge discovery and information integration from demand [7]. Li reconstructed the concept and connotation of smart senior care from a multidimensional perspective and suggested the architecture of a smart senior care service platform that makes extensive use of Internet of Things and cloud computing technologies. [8].

With the gradual aging of society, the annual mortality rate of cardiovascular diseases in China remains high and is on the rise. Sudden acute myocardial infarction and malignant cardiac arrhythmias are also associated with high rates of disability and mortality due to missed early diagnosis and treatment. However, traditional cardiac monitoring devices can only be used in hospitals, while patients' morbidity is mostly outside the hospital, which creates a temporal and spatial dislocation contradiction [9]. Smart elderly care collects and processes real-time information about the elderly in the community, relies on the comprehensive information platform for elderly care to achieve resource penetration, supervision penetration, and service penetration, provides personalized services for the elderly, and constructs an elderly care service system that coordinates with home community institution, and so forth. Using new-generation information technology such as artificial intelligence, Smart Aging collects and processes real-time data regarding the aged in the community. Relying on the comprehensive information platform for the elderly to achieve resource penetration, supervision penetration, and service penetration. It provides individualized services for the elderly and develops a senior care service system that integrates medical and recreational care and coordinates with local community institutions. Smart senior care employs clever wearable gadgets and the Internet of Things to detect the physical condition of the elderly and monitor their health in real time. The "one-touch call for help" function is used to seek help. Real-time telemedicine treatment through 5G technology. This is a new medical model of early prevention, early detection, and early treatment [2]. In comparison to the conventional model of elderly care, the benefits of intelligent senior care will be more evident. The community key monitoring population in Xintang Town, Zengcheng District, Guangzhou City, who participated in at least two annual medical examinations as part of the national basic public health service program between January 2020 and July 2021 was selected as the study population for this paper [10].

2. Material and Method

2.1. Data Resources and Selection

Selection criteria (meeting any 1 of them is sufficient): 1. Age≥ 65 years. 2. Suffering from diabetes mellitus. 3. Suffering from hypertensive disorders. Exclusion criteria: unable to cooperate with the study due to cognitive communication disorders or mental abnormalities. Finally, 5863 participants were enrolled in this study. They were separated into conventional therapy (group 1) (n=2987) and smart elderly health monitoring (group 2) (n=2876) groups, depending on whether or not they got smart elderly health monitoring. The conventional treatment group received a routine physical examination once a year without special intervention. The smart elderly health monitoring group received the following interventions through the Integrated Aging Information Platform in addition to the regular medical checkup once a year: 1. risk assessment of cardiovascular and cerebrovascular diseases. 2. Health education on cardiovascular and cerebrovascular diseases (including exercise, sleep, diet, psychology, and medication in 5 areas). At the same time, wearable ECG testing equipment was delivered to the health stations in the villages where the subjects in the Smart Aging Health Monitoring Group were located, and the physicians at the health stations were trained and educated. The ECG Remote Diagnostic Center was set up at the Zengcheng Branch of Southern Hospital to provide ECG reading services 24h a day, 7d a week.

2.2. Variable Description

This study was conducted in conjunction with the annual medical examination program of the National Basic Public Health Service. Relevant information was collected from the subjects: 1. General information, including age, gender, body mass index (BMI), lifestyle habits (smoking, alcohol intake, level of physical activity), and medical history [hypertension, diabetes]. Laboratory procedures Indicators, such as fasting blood glucose, heart rate, and blood pressure [systolic blood pressure (SBP), diastolic blood pressure (DBP)]. 3. Treatment, including treatment for hypertension and diabetes (Table 1). Blood pressure measurements were taken in accordance with the Chinese Guidelines for the Prevention and Treatment of Hypertension (2018 Revised Edition) for in-office blood pressure readings [11]. Simultaneously, the physical examination data of the individuals during their participation in the study were recorded, with the initial physical examination data serving as pre-intervention baseline data and the final physical examination data serving as post-intervention follow-up data.

Table 1. Baseline information of pre-intervention

General Information	Laboratory Test Indicators	Treatment Status
Age	FBG	Hypertensive Treatment
Gender	Heart Rate and Blood Pressure	Diabetes Treatment
BMI	SBP	
Living Habits	DBP	
Smoking		
Drinking		
Exercise		
History of hypertension		
History of diabetes		

The primary endpoint of the trial was the difference in blood pressure between pre- and post-intervention (i.e., post-intervention - pre-intervention). The secondary endpoint was the change in other cardiovascular disease risk variables, such as BMI and FBG, between baseline and post-intervention. Subjects were classified as having hypertension if any of the following conditions were met: 1. SBP≥ 140 mmHg or DBP≥90 mmHg.And1 mmHg=0.133kPa. 2. Use of antihypertensive medicine currently. 3. A definite history of hypertension in the past [12]. Subjects were classified as diabetic if any of the following conditions were met: 1. blood glucose≥7mmol/L during fasting. 2. Glycated hemoglobin≥6.5%. 3. Using glucose-lowering medicine currently 4. A definite diabetic history in the past [12].

2.3. Statistical Analysis

First, the baseline information such as general information, laboratory test indicators, and treatment status of the subjects in the two groups were compared.

Table 2. Comparison of the two groups of demographic data, laboratory examination indices, and treatment (Part 1)

Item	Group 1(*n*=2987)	Group 2(*n*=2876)	*P* value
Age/year	68.88±7.88	69.53±8.01	0.002
BMI/(kg·m^{-2})	24.43±3.47	24.28±3.69	0.123
Heart rate/bpm	73.44±11.86	72.64±11.90	0.010
SBP/mmHg	142.75±19.34	145.30±19.16	0.000
DBP/mmHg	82.32±11.42	83.65±11.44	0.000

As shown in Tables 2, 3, 4, the subjects in the smart aging health monitoring group had a higher mean age (both groups belonged to the elderly population category), higher blood pressure levels,

slower heart rates, and lower rates of diabetes treatment than those in the conventional treatment group. In addition, they were all P<0.05. The differences between groups were statistically significant for alcohol intake and physical activity. Moreover, they were each P<0.05. Not so for BMI. The quantitative information in Table 2 conforms to a normal distribution, denoted as x ± s, and is compared between groups using a t-test with two independent samples.

Table 3. Comparison of the two groups of demographic data, laboratory examination indices, and treatment (Part 2)

Item	Group 1(n=2987)	Group 2(n=2876)	*P* value
FBG/(mmol·L^{-1})	4.80(4.20,5.70)	4.71(4.16,5.62)	0.055

The Mann-Whitney U test was performed to compare groups based on quantitative data in Table 3 that did not conform to a normal distribution, as shown by the M (Q1, Q3).

Table 4. Comparison of the two groups of demographic data, laboratory examination indices, and treatment (Part 3)

Item	Group 1(n=2987)	Group 2(n=2876)	*P* value
Male/n(%)	1154(38.63)	1086(37.76)	0.509
Smoking/n(%)			0.665
Never	2483(83.15)	2393(83.23)	
Current smoker	317(10.62)	317(11.03)	
Ever smoker	186(6.23)	165(5.74)	
Drinking/n(%)			0.014
Never	2576(86.24)	2557(88.91)	
Sometimes	279(9.34)	212(7.37)	
Often	27(0.09)	17(0.59)	
Everyday	105(3.52)	90(3.13)	
Exercise/n(%)			0.000
Never	671(22.46)	974(33.87)	
Sometimes	280(9.37)	320(11.13)	
At least once a week	56(1.87)	47(1.63)	
Everyday	1980(66.29)	1535(53.37)	
History of hypertension/n(%)	2330(78.00)	2276(79.14)	0.305
History of diabetes/n(%)	747(25.01)	756(26.29)	0.275
Hypertensive treatment/n(%)	1582(83.05)	1515(52.79)	0.860
Diabetes treatment/n(%)	611(20.49)	518(18.05)	0.020

Table 4 displays the qualitative data, presented as frequencies (percentages) and compared using Pearson's chi-square test or Fisher's exact probability method.

After 227 d of intervention, the blood pressure of the subjects in the two groups before and after the intervention (Figure 1) was as follows: the mean SBP in the conventional treatment group changed from (142.75±19.34) mmHg before the intervention to (145.67±18.96) mmHg after the intervention. The difference between the change before and after the intervention was 2.92 mmHg. And the data was 95% *CI* 2.29~3.54, P=0.000. Before the intervention, the mean DBP was (82.32±11.42) mmHg and after the intervention, it was (82.21±11.06) mmHg. The change between before and after the intervention was -0.12 mmHg. And the data was 95% *CI* -0.51~0.28, P=0.554. The mean SBP in the smart aging health monitoring group reduced from (145.30±19.16) mmHg to (145.02±18.66) mmHg following the intervention. The difference between pre-intervention and post-intervention blood pressure was -0.28 mmHg. And the data was 95% *CI* -0.94~0.37, P=0.398. Prior to the intervention, DBP was (83.65±11.44) mmHg, but it was (82.98±10.75) mmHg afterward. The change in blood pressure from pre-intervention to post-intervention was -0.68 mmHg. And the data was 95% *CI* -1.09~-0.27, P=0.001. Before and after the intervention, the difference in blood pressure changes between the two groups of participants was examined. Figure 1 displays that the difference between

groups in the change in SBP before and after the intervention was 3.20 mmHg. And the data was 95% *CI* 2.29~4.11, P=0.000. Before and after the intervention, the difference in DBP change between groups was 0.56 mmHg. And the data was 95% *CI* -0.01~1.13, P=0.055.

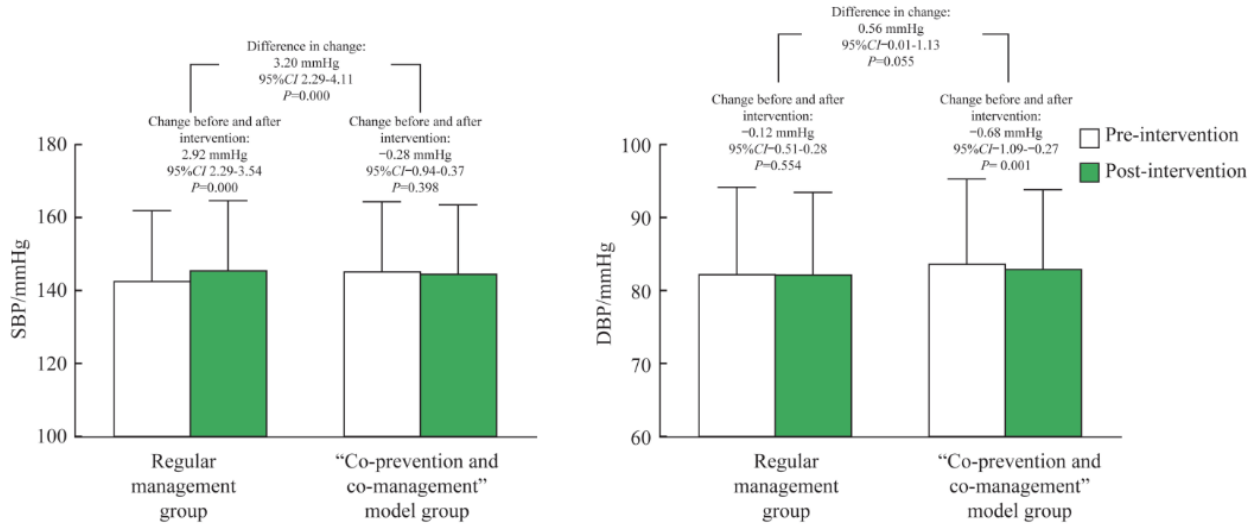


Figure 1. Changes in blood pressure before and after the intervention within each group and a comparison of the two groups [10]

Analysis of covariance showed that after correcting for pre-intervention baseline SBP. Mean post-intervention SBP was estimated to be 146.36 mmHg (95% *CI* 145.80~146.92) for subjects in the conventional treatment group and 144.30 mmHg (95% *CI* 143.74~144.87) for subjects in the smart aging health monitoring group. The latter was 2.06 mmHg lower than the former and the difference was statistically significant (95% *CI* 1.26~2.86, P=0.000). After correction for pre-intervention baseline DBP, mean post-intervention DBP was estimated to be 82.52 mmHg (95% *CI* 82.18~82.86) for subjects in the conventional treatment group and 82.65 mmHg (95% *CI* 82.31~83.00) for subjects in the smart aging health monitoring group. The latter was 0.13 mmHg higher than the former, but the difference was not statistically significant. And the data was 95% *CI* -0.35~0.61, P=0.594.

3. Results and Discussion

In Tables 5, 6, 7, the linear regression model for SBP revealed that in the uncorrected model (Model 1), the Smart Aging health monitoring model was associated with a reduction in SBP. And P=0.000. Model 2 (Table 6) was adjusted for age, sex and baseline SBP profile. In addition to model 2, model 3 (Table 7) corrects for smoking status, alcohol use, physical activity status, hypertension treatment, and diabetes treatment. Both model 2 and model 3 showed that the smart senior care health monitoring model was still associated with a reduction in SBP. And both were P=0.000. This suggests that the association between the smart ageing health monitoring model and SBP reduction is independent of these adjustment factors. However, a similar phenomenon was not observed for DBP.

Table 5. A linear regression analysis of cardio-cerebrovascular disease risk factor control and smart senior care health monitoring (Model 1)

Change of Variable	Model 1		
	β	95% *CI*	*P* value
SBP	-3.198	-4.106–-2.290	0.000
DBP	-0.557	-1.127–0.012	0.055
BMI	0.001	-0.075–0.078	0.978
FBG	0.051	-0.052–0.153	0.332

Table 6. A linear regression analysis of cardio-cerebrovascular disease risk factor control and smart senior care health monitoring (Model 2)

Change of Variable	Model 2		
	β	95% *CI*	*P* value
SBP	-2.159	-2.952–-1.366	0.000
DBP	0.209	-0.273–0.690	0.396
BMI	0.005	-0.080–0.070	0.889
FBG	0.050	-0.043–0.144	0.291

Table 7. A linear regression analysis of cardio-cerebrovascular disease risk factor control and smart senior care health monitoring (Model 3)

Change of Variable	Model 3		
	β	95% *CI*	*P* value
SBP	-2.083	-2.893–-1.273	0.000
DBP	0.163	-0.329–0.655	0.517
BMI	-0.008	-0.084–0.068	0.837
FBG	0.079	-0.014–0.173	0.095

As shown in Table 8, BMI and FBG, other risk factors for cardiovascular and cerebrovascular disease, increased in subjects in the conventional care and smart senior care healthy monitoring groups after the intervention compared to before the intervention. However, a between-group comparison of the changes in the above indicators in these two groups showed that the differences in BMI and FBG between groups were not statistically significant.

Table 8. Changes in various cardio-cerebrovascular disease risk factors in the two groups before and after the therapies, as well as a variance analysis for these variables

Change of Variable	group 1(*n*=2987)	group 2(*n*=2876)	Changes between the two groups/difference (95% *CI*)	*P* value
BMI/(kg·m^{-2})	0.18±1.51	0.18±1.47	0.00(-0.08–0.08)	0.978
FBG/(mmol·L^{-1})	0.79±1.86	0.84±2.07	-0.05(-0.15–0.05)	0.332

4. Conclusion

In this study, IoT and smart wearable monitoring devices were used to follow the cardiovascular and cerebrovascular health of a community-based monitoring population. Compared to current cardiovascular disease management (i.e., the traditional therapy group), the smart senior care health monitoring model improves blood pressure control, as measured by a 3.20 mmHg relative decrease in SBP. Through the integrated information platform for the aged, this approach simultaneously de-pauperizes on-site medical examination forms, thereby boosting the efficiency of cardiovascular and cerebrovascular illness data collecting. In addition, residents and health station personnel were educated on cardiovascular and cerebrovascular disease health knowledge and basic skill development as part of this study. It also improved the self-health management skills of residents and the management of cardiovascular and cerebrovascular diseases in primary care institutions.

There is research that describe the effects of web-based digital treatments on blood pressure. In the absence of antihypertensive medication, the Japanese HERB-DH1 study discovered that the digital therapy intervention group (HERB system + standard lifestyle changes) was more effective than the control group (standard lifestyle changes) at reducing 24-hour ambulatory, home, and office blood pressure. A randomized controlled trial conducted by LISN et al. shown that a web-based fitness and nutrition education intervention model resulted in a 1.8 mmHg reduction in DBP in individuals. And the data was 95% *CI* -0.2~-3.3, P=0.030. The randomized controlled trial conducted by MCMANUS et al. indicated that the digital blood pressure management intervention model effectively decreased SBP levels in individuals compared to the conventional treatment model. All of

this research indicates that an internet-based strategy to the treatment of cardiovascular disease has a positive impact on blood pressure control. This study's findings are consistent with those of previous research.

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