



Research paper

Analysis of health changes and the association of health indicators in the elderly using TCM pulse diagnosis assisted with ICT devices: A time series study

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ABSTRACT

Introduction: The utilization of information and communications technology (ICT) devices is a new way to record and analyze health data of the elderly. This time-series study aimed to analyze health changes, and the correlation between pulse manifestation and health indicators, in the elderly.

Methods: We conducted continuous 93-day monitoring of health data and pulse records in 8 elderly participants. A time series method was used to analyze health changes in participants. The correlation between pulse manifestation and health indicators was analyzed using a structural equation model.

Results: During the use of ICT devices, the number of steps taken by the elderly showed a significant increase ($p < 0.05$). According to the time series prediction formula, the number of steps predicted on day 94 was 8869.8. In practice, steps on day 94 were 8267.3; the difference between these values was within 10%. Personal health information, health habits, and physiological indicators had a direct impact on pulse manifestation; influence coefficients were 0.14, 0.18, and 0.05 respectively.

Conclusion: Through the use of ICT devices, we can understand the health status of the elderly and make behavior predictions. Pulse manifestation data can indicate the health status of the elderly. Thus, ICT devices can be used as health management tools and assist doctors in making simple diagnoses.

1. Introduction

In the past 100 years, almost all countries have experienced a significant increase in the average life expectancy and population [1]. In many developing countries, the increase in the elderly population has been considerably faster than in the developed countries; this is called "rapid aging." [2]. In China, the proportion of people over 60 years old is expected to increase from 12% to 40% within 50 years (from 2000 to 2050) [3]. It is predicted that in 2050, the over the age of 65 will reach 400 million (26.9% of the total population) [4]. Furthermore, the number of elderly people over the age of 60 reached 240 million in 2017, accounting for 17.3% of the total population [5]. Therefore, China will have one of the populations with the highest percentage of the elderly in the world. This will inevitably give rise to a host of medical and health challenges.

With the rapid aging of the population, the number of elderly people with chronic diseases in China is also increasing, and many residents

face serious health issues. In 2012, there were 260 million people with chronic diseases in China, and the number has increased by an average of 8.9% annually [6]. A large-scale population-based study has recently reported that more than 11% of people had 2 or more chronic conditions in 2011 [7]. A systematic review reported that the overall prevalence of multimorbidity reached 87.0% in urban residents among the elderly (aged ≥ 60 years). [8]. According to the China Health Statistics Yearbook (2011), the prevalence of hypertension in people aged 65 years or older was 66.9% in 2010 [9]. Between 1980 and 2010, the prevalence of diabetes mellitus increased from 6.7%–11.6% of the population. The prevalence of diabetes also increased from 2.09% in 1994 to 27.2% in 2010 [10]. In light of these problems, how to improve the health of the elderly has become an important social issue. The Chinese government is continuously advancing the medical health system and medical services for the elderly [11]. The use of information and communications technology (ICT) devices to measure health indicators and pulse manifestation data for the evaluation of elderly health has

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been encouraged by the government.

Traditional Chinese Medicine (TCM) has a long history and is part of Chinese culture. It is a natural, safe, effective, and widely used therapy, and is increasingly gaining global attention [12]. TCM is a form of traditional medicine that is a supplement and substitute for Western medicine widely accepted in China. Compared with Western medicine, TCM has unique advantages, such as safety, lower cost, effectiveness, and convenience, which has led to high levels of acceptance in an increasing number of countries [13]. To date, the Chinese government has formulated nearly 100 regulations to support the development of Chinese medicine, especially in the treatment and prevention of chronic diseases. [14]. It is reported that in 2013, 45% of the urban elderly were willing to choose TCM for the first diagnosis in China [15]. Pulse diagnosis belongs to one of the following four basic types of TCM examinations: inspection, listening and smelling, inquiry, and pulse diagnosis [16]. To perform pulse diagnosis, the TCM doctor touches the top of the person's radial artery to diagnose patient's health status by feeling the pulse with his or her fingertips [17]. A study indicated that pulse diagnosis exhibits the highest ratio, approximately 44%, among the four diagnostic methods [18]. Pathologic changes in an individual's body condition are reflected in the wrist-pulse manifestation. Clinical studies have shown that patients with hypertension, hypercholesterolemia, cardiovascular disease, and diabetes exhibit premature loss of arterial elasticity and endothelial function, which ultimately leads to reduced flexibility of the vasculature and increased pressure on the circulatory system. The amplitude and rhythm of the wrist vein also vary according to the hemodynamic characteristics of the blood flow [19]. TCM doctors can diagnose the overall situation of the patient through the pulse diagnosis and prescribe a suitable treatment plan. In particular, in chronic diseases, such as hypertension, pulse diagnosis in TCM contributes to pattern differentiation and therapeutic intervention [20].

Pulse diagnosis is an important diagnostic method in TCM and is performed on the radial artery bilaterally at three different positions called the “inch, bar, and cubit”. Recently, some characteristics used to describe pulse images are interpretable as parameters obtained by pulse waveform analysis such as the pulse wave velocity and augmentation index [21]. In the few last decades, pulse wave analysis using brachial tonometry and the construction of mathematical models has been used for the noninvasive assessment of anatomic and functional status of arteries [22]. Previous studies have shown that patients with a subarachnoid hemorrhage have an increased pulse wave velocity and decreased brachial artery compliance, which are reflected in the pulse [23]. TCM treatment has been commonly used to treat chronic hepatitis B in Asian countries based on pulse diagnosis [24]. Research has shown that maximum pulse amplitudes in the left Gwan and right Gwan, “L-PPI and R-PPI” respectively, were found to be good indicators of hypertension. This result supports the quantification and objectification of pulse diagnosis in TCM for complementary and alternative medicine [25].

With the continuous development of information technology, the combination of TCM diagnosis, science, and technology, has become an important topic of interest [26]. One study developed the EasiCPRS prototype and trained and validated the performance of the system by collecting and analyzing pulse manifestation data from the elderly under a variety of different health conditions. The results indicate that the system has significant utility in disease diagnosis and health care [27]. At the same time, through the development of TCM software, various conditions such as pulse diagnosis, have been classified to assist TCM doctors in improving diagnosis and treatment [28]. The new technical support for the diagnosis and treatment of TCM has established the Typical Case Management System (TCMS). TCMS collects a small amount of personal data and performs a matching analysis of TCM knowledge maps to monitor human health status for the purpose of appropriate medical treatment [29]. However, in TCM treatment, acquiring an accurate pulse can only be performed by experienced TCM

doctors [30]. Therefore, objective and digital pulse diagnosis is highly desirable. The use of ICT devices to record health indicators and pulse diagnosis information in the elderly can help us to achieve health data quantification.

In this study, we first aimed to analyze health changes in the elderly using ICT devices to record health indicators and pulse diagnosis information. Second, we attempted to predict changes in the health indicators in the elderly. Finally, we aimed to determine the association of health indicators with pulse manifestation.

2. Methods

2.1. Participants

Ten elderly adults receiving health management services in Hangzhou, Zhejiang Province, China were selected between March 15 and June 15, 2018. The sample included 5 men and 5 women, aged 65–76 years (average age 70.0 ± 3.9 years). Participants were healthy elderly people who attended a physical examination every year, and whose electronic health records suggest that they did not have chronic diseases. We used the “Power Analysis and Sample Size” calculation and determined a minimum sample size of 6 people. Eventually, 10 people were selected to participate in the study. The sample calculation formula was:

$$M = [1 + (K - 1)_p] \frac{\sigma^2(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2}{K\delta^2}$$

In the experiment, the participants wore wearable devices, and used the pulse diagnosis device to record their pulse manifestation and health data. Ethical considerations of this study were approved by the Ethical Review Committee of Waseda University Japan (ID:2017–224). All the respondents signed an informed consent form.

2.2. Data collection methods

2.2.1. Wearable devices

The health bracelet utilized in this study is presented in Fig. 1. This EHP health bracelet (Model name: EHP-A86) was produced in Shenzhen, China. The specifications of the bracelet were: main dimension, $57 \times 20 \times 13.9$ mm; weight, 24 g; Sensor, Acceleration sensor, dynamic optical sensor; and system requirement, Android 4.3+ or IOS 7+. The bracelet can detect health data (blood pressure and heart rate) and record the number of walking steps and sleep quality. The specific implementation method consisted of: (1) communicating one-on-one with elderly participants, teaching them how to wear the bracelet and use the application, and (2) using the application data export



Fig. 1. Wearable device.

<http://www.oudmon.com/index.shtml>

function, deriving and sending data to the researchers every week.

The wearable device measured the number of steps, sleep quality, blood pressure and heart rate in the elderly participants. The wearable device has a three-axis accelerometer that captures the data of the three dimensions in real time, and finally converts the data into steps by the algorithm. The bracelets recorded the patient's blood pressure and heart rate data hourly; data were recorded on the mobile application. The blood pressure and heart rate were automatically averaged daily. The number of steps in this study was counted from 0:00 to 20:00 daily. The built-in body motion recorder of the wearable device measured the quality of sleep according to the amplitude and frequency of wrist movement during sleep. The sleep quality score interval is 0–100. The wearable device estimated the blood pressure by collecting the pulse waveform, the rising slope of the pulse wave, and the band time by a photoelectric sensor. The green light-emitting diode (LED) light of the wearable device was matched with a photodiode to illuminate the subcutaneous blood vessels of the wrist. Through the principle of blood reflecting red light and absorbing green light, wearable devices measure blood flow and calculate the heart rate.

2.2.2. TCM pulse diagnosis device

We used the TCM pulse diagnosis device to record pulse data weekly. Pulse is a TCM term that refers to pulse position, strength, and rhythm. We used the DS01-C Information Collection System of Pulse Condition Diagnosis (Shanghai FDA Food and Drug Administration No. 20152270429), shown in Fig. 2. This system was applied to collect pulse condition diagnosis information; it recorded or saved the pulse feature changes in different periods. Pulse parameters are presented in Table 1, Fig. 4, and Fig. 5. Each measurement contains 1 pulse, approximately 2 min per phase.

The standard pulse acquisition procedure is as follows: (1) the staff senses the pulse position and marks it; (2) the staff wears the pulse position fixer; (3) the staff installs the pressure sensor; (4) the sensor follows the "floating, medium, sinking" method of compression pulse measurement and; (5) pulse diagnosis data is preserved in the software (Fig. 3).

2.3. Research quality control

All personnel involved in this investigation underwent rigorous training and assessment. During the investigation, data on the elderly were recorded accurately, and the notes and recording methods were



Fig. 2. DS01-C Information Collection System of Pulse Condition Diagnosis (Shanghai FDA Food and Drug Administration No. 20152270429) <http://www.daosh.com/product/detail.aspx?id=3>.

maintained in the research office. The results of the daily investigations were audited so that abnormalities in the data could be verified in a timely manner. The pulse diagnosis device recording method was confirmed by a TCM doctor. As two bracelets were found to be defective during the research process, the final statistical analysis included only 8 individuals. The health dataset collected included 744 values.

2.4. Statistical analysis

R version 3.5.1 and SPSS 22.0 were used for the statistical analysis. The data were expressed as " $\chi \pm s$." The experimental time was divided into 3 months. Based on the confirmation of the homogeneity of variance, a one-way repeated measures analysis of variance (ANOVA) was used to evaluate changes in the number of steps, blood pressure, sleep, and heart rate during the period when the wearable devices were used. We used the Box-Jenkins method to construct an autoregressive integrated moving average (ARIMA) model to predict changes in health indicators. The structural equation model (SEM) was used to analyze causal associations between health indicators and pulse information. First, we preprocessed the data. After preprocessing, a domain model was applied to personal data; this model represents the relationship between the data and was used to verify the relationship between variables or assumed latent factors in the SEM.

3. Results

3.1. Health status of the elderly participants

The health statuses of the elderly participants are presented in Table 2. They showed a habit of walking every day. Those over 70-years-old took fewer steps compared with those under 70-years-old. The average blood pressure was high, but within the normal range. All other health condition data showed healthy levels. Sleep scores were mostly in the range of 70–80, and the application suggested that the quality of sleep was good. Heart rates were maintained at 70–80 beats/min.

3.2. Changes in health status during the study

The experimental period was divided into 3 periods according to the month, and changes in the number of steps, blood pressure, and heart rate were statistically analyzed (Table 3). The repeated measures one-way ANOVA, using the Holm method, indicated that the number of steps had significantly changed (Fig. 4). There was no significant change in sleep, heart rate, or blood pressure. However, the average daily number of steps taken had increased significantly in the third month compared with the previous two months.

The time series method was used to map the changes in the number of steps taken by the elderly participants (Fig. 5). However, no obvious trend was observed. After performing a natural logarithmic transformation on the values, we used the Box-Jenkins Method to construct the ARIMA (p, d, q) model and determine the difference of 1 ($d = 1$). The software derived the autocorrelation figure (Fig. 6), the partial autocorrelation figure (Fig. 7), and set the values of p and q according to the reference legend ($p = 1, q = 1$). The model was confirmed as ARIMA (1, 1, 1). The ideal equation for this model was:

$$\begin{cases} y(t) = x(t) - x(t-1) \\ y(t) = a_1 \cdot y(t-1) + u(t) - b_1 \cdot u(t-1) \end{cases}$$

After model derivation (Table 4), the actual prediction equation was:

$$\begin{aligned} \{x(t) - x(t-1)\} - 21.435 &= 0.117 \times [\{x(t-1) - x(t-2)\} - 21.435] \\ &+ u(t) - 0.994 \times u(t-1) \end{aligned}$$

It was predicted that the number of steps on day 94 should be

Table 1
Explanation of the pulse diagram.

Pulse wave (time)	Physiological explanation	Pulse amplitude	Physiological explanation
t1 (Starting point to the main peak point)	Rapid ejection of the left ventricle	h1 (Main amplitude)	Aorta compliance and strength
t2 (Starting point to the main wave gorge)	Heartbeat state	h2 (Main wave gorge amplitude)	Reflecting arterial elasticity
t3 (Starting point to re-pulse front wave)	Heartbeat state	h3 (Pre-pulse amplitude)	Reflecting arterial elasticity
t4 (Starting point to drop point)	Systolic phase of the left ventricle	h4 (Drop amplitude)	Peripheral resistance of arterial vessels
t5 (Drop to the end point)	Diastolic phase of the left ventricle	h5 (Heavy stroke amplitude)	Aortic elasticity

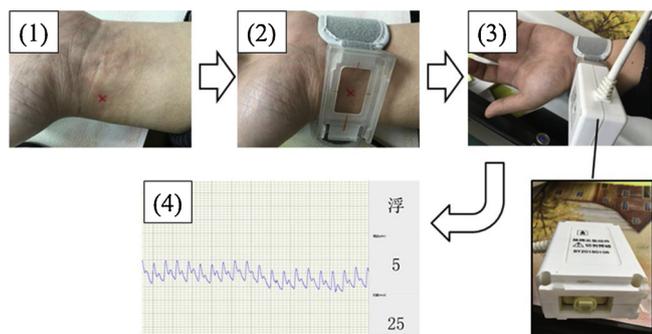


Fig. 3. The standard pulse acquisition procedure.

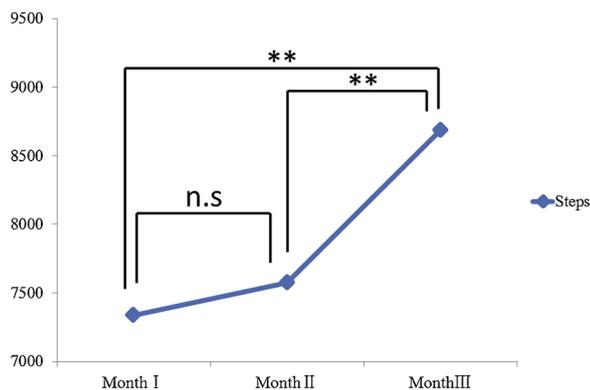


Fig. 4. Change in the number of steps taken over 3 months.

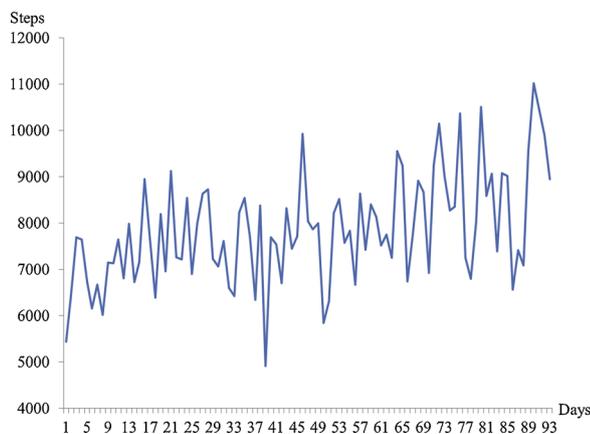


Fig. 5. Changes in the number of steps taken over 93 days.

8869.8 (Fig. 8).

3.3. Correlation between pulse and health indicators

Weekly pulse data was aggregated with health data for the corresponding date. The pulse data included pulse time (t1, t2, t3, t4, and t5), pulse amplitude (h1, h2, h3, h4, and h5) and pulse characteristics

(position, strength, rate, and rhythm). The pulse position refers to either "floating, medium, or sinking". The pulse strength refers to either "powerful, medium, or lack". The pulse rhythm refers to the "pitch of the pulse", meaning the ratio of the pulse line per minute. The pulse rate refers to the number of beats per minute. Health data included personal information (age, sex, and body mass index [BMI]), health habits (steps and sleep scores), and physiological indices (heart rate and blood pressure). This classification was approved by a TCM doctor. The pulse data and health data were imported into the structural equation model (Fig. 9; GFI = 0.716, RMSEA = 0.124). We adjusted the model and deleted the worse coefficient. "Sex" was deleted due to the sample size, which can cause errors. "Position" and "Strength" were deleted because they did not provide quantitative data. The correlation between pulse and health indicators is shown in Fig. 10; GFI = 0.858, RMSEA = 0.093. The influence of personal information, health habits, and physiological indices on pulse was 0.14, 0.18, and 0.05, respectively.

According to the adjusted model, the SEM equation was:

$$Pulse = Pulse\ time \times (-0.48) + Personal\ information \times 0.14 + Health\ habit \times 0.18 + Physiological\ indices \times 0.05 + e_{24}$$

4. Discussion

This time-series study analyzed health changes and the correlation between pulse manifestation and health indicators in elderly participants using TCM pulse diagnosis assisted with ICT devices. This study used the time series method to successfully predict the health behavior (steps) of the elderly. In addition, it also quantifies the correlation between pulse manifestation and health indicators, and presents an innovative combination of TCM and ICT devices.

4.1. Changes in elderly health status

The use of wearable devices can quantify health indicators of the elderly and record health conditions [31]. The elderly participants in this study had a relatively stable walking habit and walked more than 6000 steps per day. This met the recommendations for adults in the Chinese Dietary Guidelines [44]. During the use of the wearable devices, changes in the health data of the participants were recorded. During the study, the number of steps increased significantly. When using the wearable device, the elderly could see their own health data through the display of the application. They could also set personal goals, thereby increasing participation enthusiasm. A previous study has shown that the health awareness of the elderly is related to an accurate grasp of their health condition [32]. Another study showed that walking more than 4 h per week can reduce the risk of cardiovascular disease and improve the health of the elderly [33]. This promotes the importance of the elderly achieving independent health management. Walking is the most common exercise for the elderly; therefore, recording the number of steps taken forms an integral part of their personal health data. In the future, the health level of the elderly can be evaluated along with other health data when determining health influence factors.

Table 2
General health information of the elderly participants.

Participant ID	Age	Sex	Steps	Sleep (score)	HR (min)	SBP (mmHg)	DBP (mmHg)
A	65	Male	9450.3 ± 2696.8	71.78 ± 7.99	73.70 ± 4.55	130.69 ± 5.84	87.45 ± 4.77
B	68	Male	8136.7 ± 3271.1	73.12 ± 13.26	77.43 ± 4.91	128.77 ± 5.79	86.08 ± 6.45
C	68	Male	6922.8 ± 2939.1	74.78 ± 8.77	77.66 ± 4.76	137.33 ± 4.42	98.05 ± 7.38
D	75	Male	6429.2 ± 2636.7	81.26 ± 6.33	69.15 ± 6.32	134.68 ± 6.50	87.55 ± 4.85
E	72	Female	6998.1 ± 2537.2	80.41 ± 6.01	69.71 ± 5.93	130.11 ± 5.68	82.96 ± 4.67
F	76	Female	5932.7 ± 2346.7	77.13 ± 4.33	69.72 ± 6.12	136.75 ± 5.09	87.75 ± 4.86
G	67	Female	9282.6 ± 3266.9	74.69 ± 8.53	70.78 ± 5.63	127.65 ± 4.88	82.80 ± 4.82
H	69	Female	9575.9 ± 3242.4	65.59 ± 9.18	69.28 ± 6.19	127.31 ± 4.87	82.99 ± 4.69

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate.

Table 3
Health status of the elderly participants by month (one-way ANOVA).

Variable	S.V	SS	df	MS	F	p
Steps	subj	45920273.16	7	6560039.02		
	Month	8295723.00	2	4147861.50	21.38	**
	s ^a Month	2715654.33	14	193975.30		

Total: 56931650.5 p < 0.10.

* p < 0.05.

** p < 0.01.

4.2. Prediction of changes in the number of steps taken

Time series studies were originally used to predict economic conditions. With the development of the discipline, it has gradually been applied to the health field. A Spanish study provided a mathematical model to predict the influenza situation in Spain in the second year of the outbreak and provided recommendations for disease prevention [34]. In a study on the management of rectal cancer in the elderly, a time series method enabled the quality of life of elderly participants over a 12-month period to be effectively evaluated and assisted the oncology team in treatment decision making [35]. In the present study, the number of steps taken predicted on day 94 was 8869.8. In practice, the number of steps taken on day 94 was 8267.3. The difference between the predicted step number and the actual step number was controlled within ± 10%. A previous study found that when the number of steps taken by the elderly declines, the main cause of accidents may be due to the reduction in physical function and a fear of falling [36]. When the elderly establish a health habit, the occurrence

of an abnormal value can indicate a problematic health status. Wearable devices have been proposed for the health management of the elderly. They can be used to record health data and to assess health [37]. Incorporating the time series method into wearable devices can predict the range of steps taken by an elderly person in a given period of time in the future, providing a reference to the number of daily steps taken. In the case of an abnormal number of steps, there may be a reminder function, suggesting that the current situation of the elderly may change.

4.3. Correlation between pulse and health indicators

Based on the concept of TCM, the pulse is the main indicator of human health. The association between pulse waves and hemodynamic parameters has been previously studied in hypertensive patients, and findings indicated that blood pressure values can be predicted by pulse waves. Pulse waves and blood pressure values are closely associated [38]. Previous studies investigating pulse research have mainly analyzed the correlation between pulse and specific physiological indicators, such as heart rate and blood pressure, and then explained the relationship between pulse and health [39]. In addition to physiological data, the present study incorporated personal health information and health habits, and comprehensively explained the relationship between pulse and health. Age and BMI were classified into personal health information and were used to explain the effects on the pulse. With aging, the health of the elderly should change accordingly. A study has shown that there is a significant correlation between TCM body constitution, and being overweight, obese, or underweight. Furthermore, the pulse can reflect the TCM constitution of the elderly [40]. Based on

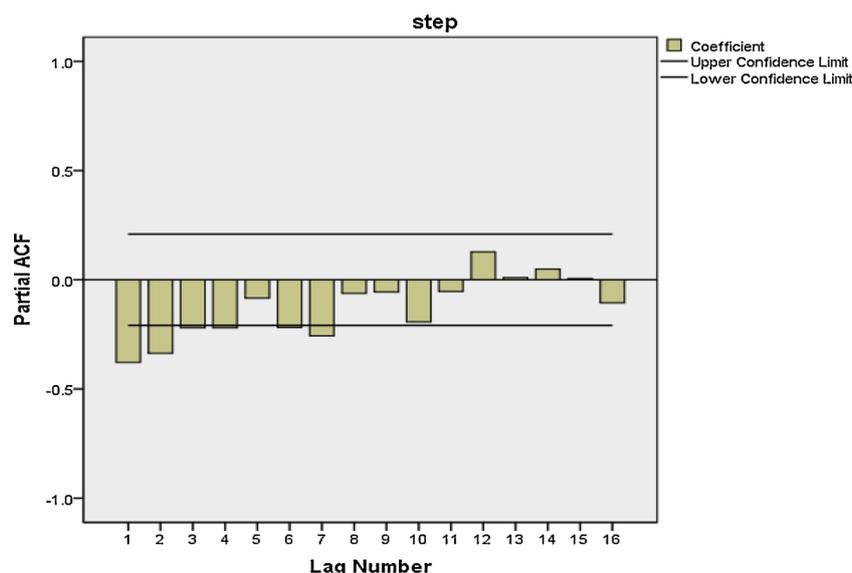


Fig. 6. Autocorrelation of changes in the number of steps.

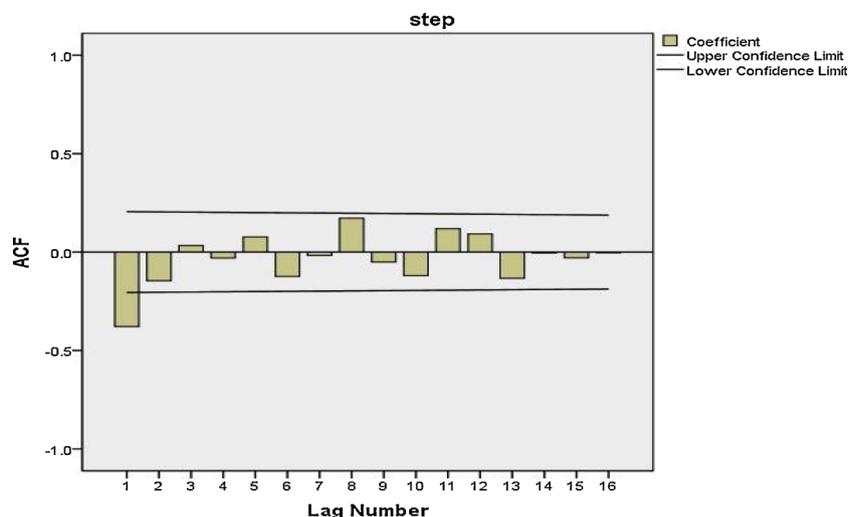


Fig. 7. Partial autocorrelation in changes in the number of steps taken.

Table 4
ARIMA model parameters.

		Estimate	SE	t	p
Step	Constant	21.435	6.025	3.558	0.001
	AR Lag1	0.117	0.119	0.986	0.327
	Difference	1			
	MA Lag1	0.994	0.299	3.324	0.001

the SEM findings, personal health information can affect the pulse. This is also consistent with the process in which TCM doctors diagnose health problems the elderly. Before diagnosis, the TCM doctor needs to know the age, height, and weight of the patient; acquiring this information is referred to as the stage of “inquiry”. Steps and sleep are classified into health habits and used to explain the effects on the pulse. A previous study has shown that elderly individuals who walk regularly or practice Tai Chi have a good constitution and a relatively stable pulse [41]. In terms of sleep, TCM pulse diagnosis is mainly reflected in the diagnosis of sleep quality (insomnia). A decrease in sleep quality can result in a change in pulse rate [42]. The present study found that healthy habits have a significant impact on pulse. Improving health habits helps to produce a healthy pulse and leads to good health statuses in the elderly. Heart rate and blood pressure are classified into physiological indices and can be used to explain the effects on the pulse. Pulse diagnosis is used to assess the dialectical treatment and quality of life of patients with chronic coronary heart disease. The pulse can be used as one of the criteria for feedback on cardiac function [43]. The strength of vascular function is one of the principles developed by the pulse diagnosis device. Based on SEM, physiological indices can also

affect the pulse. When the heart rate and blood pressure of the elderly are abnormal, the pulse will be abnormal. In a diagnosis using TCM, after the TCM doctor finds that the patient's pulse is abnormal, he or she is advised to perform an electrocardiogram or other tests to confirm the diagnosis. As a convenient diagnosis and treatment method, the TCM pulse diagnosis can offer feedback on the health status of the elderly. It is more suitable for use in primary medical institutions and for helping the elderly achieve self-health management.

From the perspective of TCM, the pulse is divided into four aspects: position, rapid, physique, and tendency [45]. It is related to the frequency, rhythm, location, length, and width of the pulse as well as the smooth fluency of the blood flow and the strength of the heart rate. The main quantifiable core parameter of the pulse is the speed. The difficulty in defining core parameters is how to correlate the pulse with human health indicators. In previous studies, the pulse was mainly associated with the symptoms of the disease [46]. Especially for patients with heart disease, their pulse is specific [47]. We believe that the use of pulse data for a special age group is a way to summarize the standardization of the pulse.

This study has some limitations. First, the research sample size was not large enough, which means that the results are not sufficiently representative of the population; however, it is sufficiently representative of the group. Second, the factors affecting the pulse, such as emotion, were not comprehensive, and psychological factors should be taken into account in future research. Third, according to the feedback from participants, the comfort of the ICT devices needs to be improved; otherwise, a lack of comfort may lead to the participants withdrawing from the experiment.

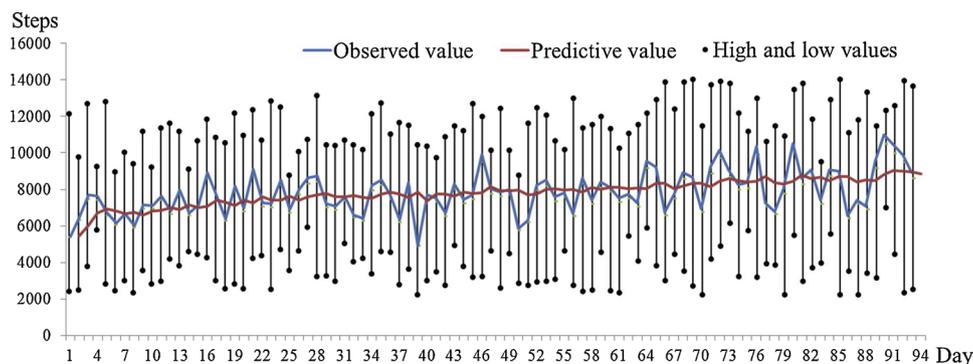


Fig. 8. Changes in the number of steps taken: trend and predictive values.

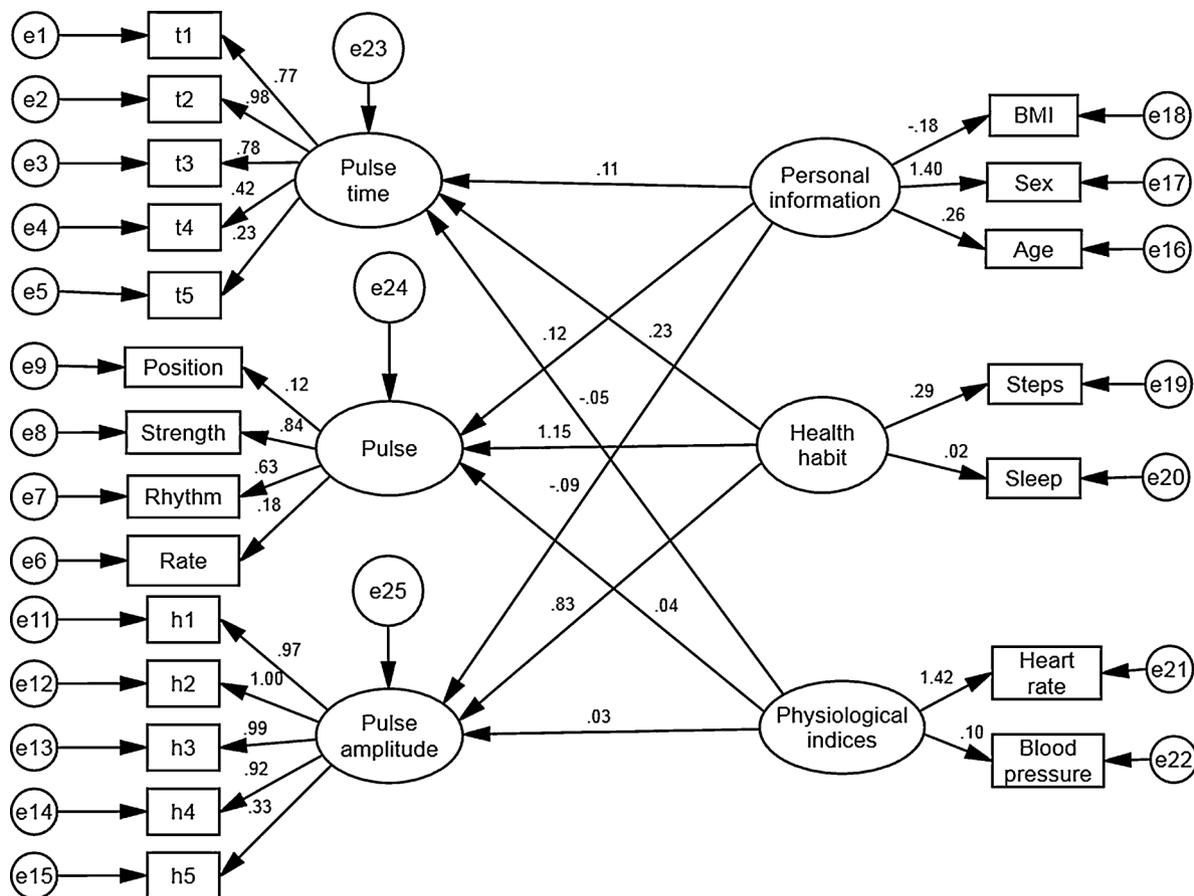


Fig. 9. Association of pulse and health indicators (model unadjusted). pulse time (t1, t2, t3, t4, and t5), pulse amplitude (h1, h2, h3, h4, and h5), body mass index (BMI).

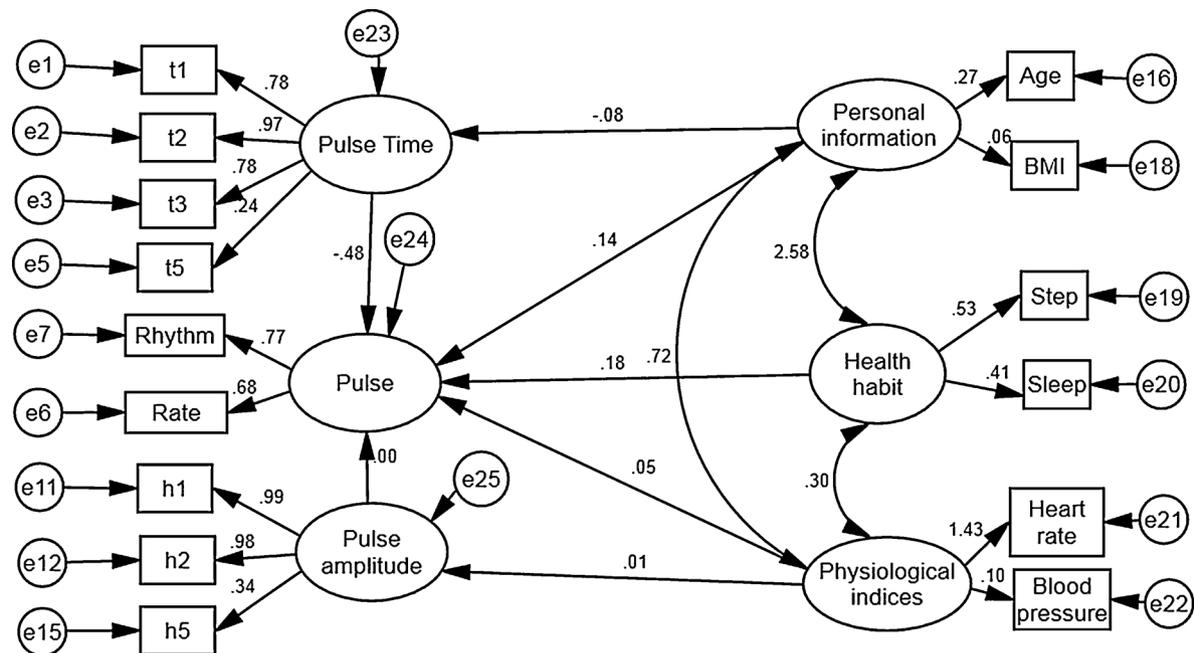


Fig. 10. Association of pulse and health indicators (model adjusted). pulse time (t1, t2, t3, t4, and t5), pulse amplitude (h1, h2, h3, h4, and h5), body mass index (BMI).

5. Conclusion

With the development of information technology, ICT devices have become integrated into daily life. They can be used to record health data and perform simple analyses in the elderly. This study utilized wearable devices to record daily health indicators in the elderly and predicted the number of steps that would be taken. When the actual number of steps taken in the elderly is significantly different from the number of predicted steps taken, we can suspect that elderly individuals have encountered health problems and adopt remedial measures. We used the pulse diagnosis device to record pulse data of the elderly; the pulse reflects on health information, health habits, and physiological indices of the elderly. In primary care institutions, the elderly can evaluate their own health through the results of the pulse diagnosis device and choose whether to conduct other examinations. Also, TCM doctor can use the data from the pulse diagnosis device for diagnostic reference.

Overall, this study suggests the use of the ICT devices may help the elderly to define their health status and achieve health management. This will also enable health professionals to improve how they monitor health changes in the elderly. In the future, it will be possible to use ICT devices to achieve health management in the elderly. Based on this study, we plan to extend the observation time in the future to obtain health data for the elderly for 1 year. In addition, we will try to include other TCM diagnostic methods like tongue diagnosis and face diagnosis to explore the relationship between the overall TCM diagnosis and treatment and the health indicators of the elderly.

Conflicts of interest

There are no conflicts of interest for all the authors.

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