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A web-based self-care program to promote healthy lifestyles and control blood pressure in patients with primary hypertension: A randomized controlled trial

Ting-Yu Chen PhD, RN[1] | Chi-Wen Kao PhD, RN[2] | Shu-Meng Cheng PhD, MD[3] | Yue-Cune Chang PhD[4]

[1]Department of Nursing, Chang Gung University of Science and Technology, Chiayi, Taiwan

[2]School of Nursing, National Defense Medical Center, Taipei, Taiwan

[3]Division of Cardiology, Department of Internal Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan

[4]Department of Mathematics, Tamkang University, Taipei, Taiwan

Correspondence
Chi-Wen Kao, No.161, Sec. 6, Minquan E. Rd., Neihu Dist., Taipei 11490, Taiwan.
Email: chiwenkao@ndmctsgh.edu.tw

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Abstract

Background: Hypertension is a major risk factor for cardiovascular diseases, which contributes to the worldwide mortality rate. Successful blood pressure control requires adherence to medications and lifestyle modifications. However, motivating patients with primary hypertension to change and sustain behaviors long-term is challenging. A web-based self-care program centered on self-efficacy theory could provide feedback for effective control of blood pressure.

Purpose: To examine the effect of a web-based self-care program for patients with primary hypertension on cardiovascular risk-factors (pulse pressure and lipids), self-efficacy, and self-care behaviors (medication adherence and lifestyle).

Design: A two-armed randomized controlled trial with 3-month and 6-month follow-ups.

Setting and Participants: A total of 222 patients with primary hypertension were recruited between February 2017 and August 2018 at a cardiology clinic of a medical center in Taipei, Taiwan.

Methods: Eligible patients were randomized by permuted block randomization into the intervention group ($n = 111$) and control group ($n = 111$). Patients in the intervention group received a 6-month web-based self-care program, based on the theory of self-efficacy, while patients in the control group received usual care. Baseline and outcome measures (3 and 6 months) included self-efficacy, evaluated with the Chinese version of the 6-item Self-Efficacy for Managing Chronic Diseases (SEMC6), self-care, using subscales of the Hypertension Self-Care Activity Level Effects Scale (H-SCALE) for lifestyle and medication adherence, and blood pressure and serum lipid data, collected through web-based self-reports and chart review. Generalized estimating equations evaluated the effects of the intervention.

Findings: At baseline, the control group had higher scores on the SEMC6, and lower cholesterol (HDL) compared with the intervention group ($t = -2.70$, $p < 0.05$; and $t = 1.76$, $p < 0.05$, respectively). Pulse pressure decreased significantly ($\beta = -20.30$, 95% CI −23.76, −16.83), and serum triglycerides and low-density lipoprotein cholesterol levels were significantly lower compared with controls at 6 months (all $p < 0.001$).

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At 6 months, the intervention group had significantly higher mean scores for the SEMC6 compared with the control group (β = 21.84, 95% confidence interval [CI] 19.25, 24.42) and H-SCALE subscale for medication adherence, diet, weight management, and physical activity compared with controls at 6 months (all, $p < 0.001$).

Conclusions and clinical relevance: The greatest benefit of this program was allowing participants to immediately consult with the researchers about self-care issues via the website. Lifestyles vary from person to person; therefore, the individuality of each participant was considered when providing feedback. We provided devising interventions for participants that would increase their confidence in self-care for hypertension and ultimately achieve home blood pressure control. We encourage incorporating this program into standard clinical care for patients with hypertension.

KEYWORDS
diet, hypertension, physical activity, self-care, self-efficacy, web-based, weight management

INTRODUCTION

Hypertension remains one of the leading causes of death from non-communicable diseases worldwide, causing 10.4 million deaths annually (GBD 2017 Risk Factor Collaborators, 2018). Half of the global cardiovascular events are caused by hypertension, and 45% of deaths from cardiovascular disease and 64% of cerebrovascular accidents are related to poor blood pressure control (Feigin et al., 2017; Williams et al., 2018). In Taiwan, the prevalence of hypertension is 53.4% (Pan et al., 2020). The standardized mortality rate per 100,000 people was 13.4% in 2019, and the number of deaths due to hypertension increased significantly by 10.1% compared to a decade ago, accounting for 18.2% of the standardized mortality rate for males and 9.2% for females, with one in every 4.5 deaths directly related to hypertension (Ministry of Health and Welfare, 2021). Worldwide, less than one-fifth of this population has adequate blood pressure control, with ideal blood pressure control in approximately 50% of patients in high-income countries and 25% in low-middle-income countries (Burnier & Egan, 2019).

National and international guidelines for the treatment and regulation of hypertension recommend not only medication adherence, but also applying lifestyle modifications for ideal blood pressure control, which requires adequate self-care behavior (Chiang et al., 2015; Chobanian et al., 2003; Williams et al., 2018). According to The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, six self-care behaviors are recommended for patients with hypertension: adherence to medication prescriptions, and five self-care behaviors related to lifestyle modifications. Life-style modifications are one of the most important means of controlling blood pressure (Cheng et al., 2020), which include the following: (1) maintaining a healthy diet, such as the DASH diet (Dietary Approaches to Stop Hypertension); (2) engaging in physical activity; (3) maintaining a healthy weight; (4) reducing alcohol intake; and (5) avoiding tobacco (Chobanian et al., 2003). A longitudinal study showed that a DASH-style diet, physical activity, and a BMI within the normal range prevented 38% of women and 43% of men from developing hypertension (Bai et al., 2017). The 2019 ACC/AHA guidelines also stated systolic blood pressure (SBP) can be reduced by adhering to the DASH diet by 11 mm Hg, weight control by 5 mm Hg, and increasing physical activity by 5–8 mm Hg (Arnett et al., 2019).

There is also growing evidence that increased pulse pressure (PP) can represent increased arterial stiffness; thus it can be used to predict cardiovascular disease and all-cause mortality (Said et al., 2018). A meta-analysis of prospective observational studies demonstrated a wide PP was associated with greater risk of cardiovascular and all-cause mortality (Zhao et al., 2014). Another meta-analysis showed that every 10 mmHg increase in PP was related to an increased risk of stroke (Liu et al., 2016).

According to the Behavioral Risk Factor Surveillance System, only 1.7% of individuals with hypertension in the United States follow a healthy lifestyle, and failure to comply with treatment suggestions is a major obstacle to achieving optimal blood pressure control (Fang et al., 2016). In addition, a meta-analysis of studies from 15 countries, which included 12,603 participants, found medication non-adherence was prevalent in 45.2% of patients with hypertension, with 43.5% of those patients living in Asia (Abegaz et al., 2017). Adherence to medication and self-care behaviors has been proved to be a key factor for blood pressure control (Burnier & Egan, 2019), and self-efficacy can affect hypertensive patients' adherence to treatment. (Hu et al., 2015; Shen et al., 2020). Participants with high self-efficacy demonstrated more motivation for maintaining long-term health behaviors (Kawamura et al., 2018). The self-efficacy was a significant mediator of medication adherence (Shen et al., 2020). A meta-analysis of 12 studies on self-management interventions for patients with hypertension found self-efficacy and medication adherence increased, and BMI, SBP, and DBP decreased compared to the control group (Van Truong et al., 2021).

Theoretically based educational interventions have been shown to be successful at helping patients with hypertension control their blood pressure (Tam et al., 2020). Bandura's theory of self-efficacy suggests an individual's confidence in their abilities to accomplish a

specific goal, including confidence to perform an activity when obstacles arise, and beliefs in their ability to perform a particular action (Bandura, 1977). Enactive attainment, vicarious experiences, verbal persuasion, and somatic and affective states can all influence self-efficacy (Bandura et al., 1999). The acquisition of skills related to self-care is more attainable when a person is highly confident in their ability to perform a specific behavior through explicit instructions, skills, training, or demonstration of the desired behaviors (Ministry of Health Guideline Group New Zealand, 2011). Fostering and sustaining self-care skills and increasing confidence in self-efficacy can be augmented by providing support from technological devices, such as mobile phones, tablets, and text reminders. This technological support can make it easier for patients to apply self-management of their disease in a home setting, rather than depending on feedback from clinical staff, thus allowing lifestyle behavior changes to be more sustainable, and goals more easily achieved (Li et al., 2020; Nolan et al., 2018; Tam et al., 2020).

Self-care programs have been shown to help patients with hypertension increase their self-efficacy for blood pressure control. However, few theoretically based self-care programs for patients with hypertension are available in Taiwan. Therefore, guided by Bandura's theory of self-efficacy (Bandura, 1977), this study aimed to investigate the effectiveness of a web-based self-care program to improve self-efficacy and self-care behaviors. Our primary hypothesis was that patients received the web-based self-care program in the intervention group would have better control of pulse pressure compared with the control group at 3- and 6-month follow-ups. Our secondary hypothesis was that patients in the intervention group would have better control of blood lipids and show greater improvements in self-efficacy and self-care abilities compared with the control group after 3 and 6 months. The framework for this study and outcome measures are shown in Figure 1.

METHODS

Study design and sample

This study was a two-armed, parallel-group, double-blind, randomized controlled trial with a 3-month (T1) and 6-month (T2) follow-up. Patients who were admitted to the cardiology outpatient clinic of a medical center in Taipei from February 2017 to August 2018 and met inclusion criteria were eligible to participate in the study. The inclusion criteria were as follows: aged 20–79 years, with primary hypertension (SBP ≥ 130 mm Hg or DBP ≥ 80 mm Hg) diagnosed by a physician, had not previously participated in a self-care program, had access to a smartphone or tablet, had a sphygmomanometer at home, and could read Chinese. Patients were excluded if they had cardiac arrhythmia, malignant hypertension, familial hypercholesterolemia, alcohol addiction, substance abuse, a major psychiatric disorder, a terminal illness, thyroid and renal disease, or were pregnant.

The initial invitation to participate in the study was sent by the patients' attending physician. Patients who expressed interest in participating were referred to the project facilitator who explained the study objectives and procedures. A total of 356 patients expressed interest in participating. However, 134 patients were excluded for the following reasons: 18 did not meet the inclusion criteria, and 116 declined to participate due to lack of time. A total of 222 patients met the inclusion criteria and agreed to participate.

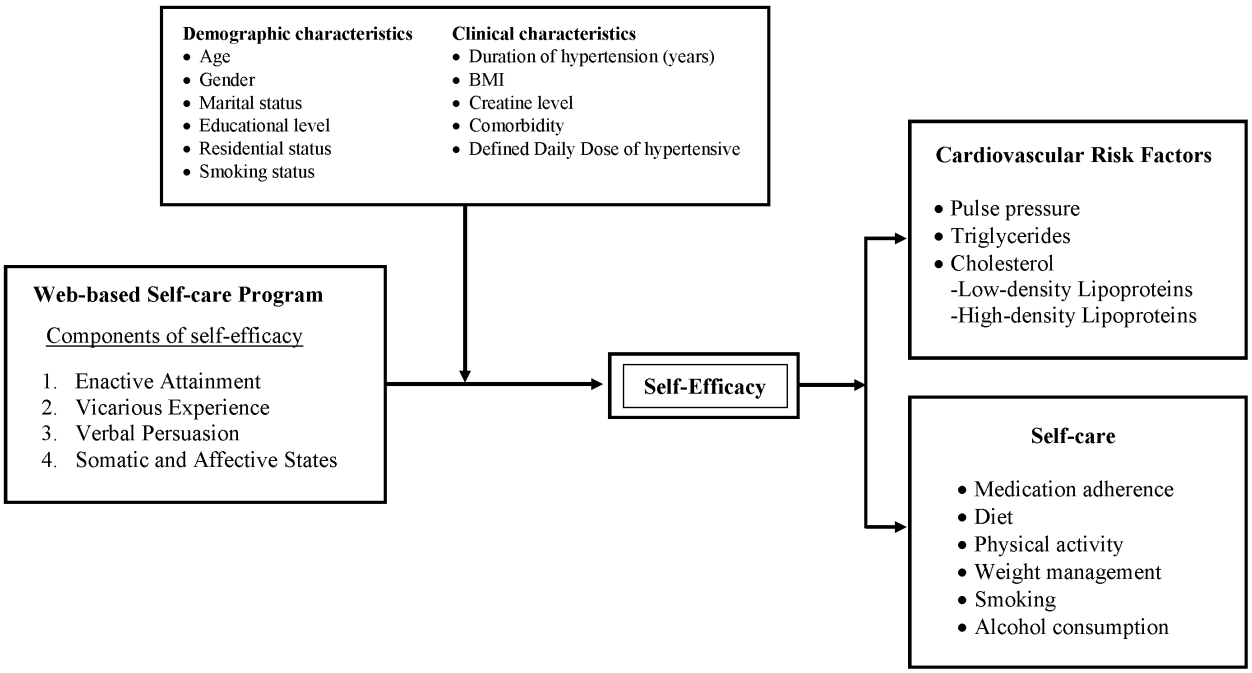

FIGURE 1 Research framework of the web-based self-care program

Sample size was determined with G*Power computer software with 90% power, assuming a mean difference in blood pressure of at least 5-mm Hg and a standard deviation (SD) of 17 mm Hg between the intervention and control groups, based on the results of a study conducted by McManus et al. (2014), and significance (α) of 0.05 with a two-tailed. We estimated the attrition rate at 20%, which indicated a sample size of at least 96 per group was required. The study was approved by the Institutional Review Board (IRB) of the hospital (IRB 2-104-05-148) before enrollment.

Participants were randomly assigned to one of two groups using a permuted block randomization design with a block size of four. The random allocation was concealed from participants and outcome evaluators using sequentially numbered opaque envelopes. Neither the intervention group (n = 111) nor the control group (n = 111) knew how their treatment conditions differed from the other group. The study is registered at clinicaltrials.gov as NCT03470974.

Development of the web-based self-care program

The web-based self-care program was developed based on the literature involving Bandura's self-efficacy theory (Bandura, 1977) as well as national and international guidelines for the management of hypertension (Chiang et al., 2015; Chobanian et al., 2003; Williams et al., 2018). This literature emphasizes that self-efficacy has a strong influence on maintaining healthy lifestyle behaviors and self-care management, therefore theoretically based strategies were incorporated into the intervention to initiate, improve, and maintain participants' healthy lifestyle behaviors, achieve good blood pressure control at home and reduce the risk factors of cardiovascular events in the long term (as Table 1).

For this web-based self-care education program, the researcher explained to participants that they would receive in person, face-to-face education sessions four times over the month, which would each last about 30–40 min. Participants were also provided with individual login accounts and passwords that would be used to access a non-public website, which interfaced with the self-care program. The program included three parts, described below.

Getting motivated and setting home blood pressure control goals

The first part of the self-care program required participants to fill out the H-SCALE and discuss which aspect of lifestyle should be modified first, which would be determined by their results and blood test values. Next, we used a video on the website to introduce self-care behaviors for control of hypertension, tailored to their specific needs. Participants were instructed to practice these lifestyle changes daily. Finally, they were instructed to set their own goals for home blood pressure control and to enter these goals in the section of the web entitled “blood pressure values”.

Self-monitoring and acquiring new experiences

Participants entered their daily blood pressure values on the website which allowed them to maintain a visual record of their progress and they also received verbal encouragement from the research team, who also monitored their progress. The team also responded immediately with suggestions for modifications, if the participant's blood pressure was not well-controlled.

If participants encountered barriers to home blood pressure control, they were encouraged to share their own experiences or learn from others via a message board on the website. In addition, the website system sent weekly or monthly blood pressure values to family members (with the permission of the participant), which allowed the participant to receive support to change and maintain their behavior.

Developing coping skills and maintaining healthy behavior

The third part of the self-care program was designed to sustain participants' confidence in their ability continue with healthy behaviors. As each participant came closer to reaching the goal they had set, their confidence in home blood pressure control increased, which provided positive feedback about their self-efficacy to maintain their new behavior long-term. Participants were also encouraged to share their opinions and experiences with others on the website's message board.

The self-care website

We developed a secure and non-public website to assist the participants with implementing and maintaining control of their home blood pressure. The web interface was comprised of five sections entitled: (1) Basic personal information, for entry of age, gender, address, phone number(s), occupation, and dates of next scheduled visits; (2) blood pressure values; and (3) self-care education, which included a video on hypertension control; (4) personal blood test measures, where we reviewed patients' medical charts and entered values of triglycerides, low-density, and high-density lipoprotein cholesterol (LDL-C and HDL-C, respectively) serum creatinine, and fasting blood glucose levels; and (5) participant message board, where the participants could leave anonymous messages to share their experiences with home blood pressure control (Kao et al., 2019).

The home blood pressure control video

We created a video on home pressure control based on national and international hypertension guidelines (Chiang et al., 2015; Chobanian et al., 2003; Williams et al., 2018), which was reviewed by five experts

TABLE 1 Components of the 6-month web-based self-care program: Components of self-efficacy, application strategies for participants, and fours sources of self-efficacy

Components of self-efficacy theory	Strategies and application	Sources of self-efficacy
Enactive Attainment	• Evaluate current lifestyle on the H-SCALE subscales • Describe the importance of a healthy lifestyle for good blood pressure control. • Discuss the aspects of lifestyle improvement and the major barriers to implementation. • Expected blood pressure control goal set at home. • Home blood pressure values entered on the website	• Face-to-face interactions • Link to website program • Hypertension control video
Vicarious Experiences	• Describe the common complications of poor blood pressure control. • Sharing experiences with other patients	• Face-to-face interactions • Link to website program • Hypertension control video
Verbal Persuasion	• Tailor strategies for self-implementation of each patient. • Obtain encouragement of positive behaviors from experts. • Obtain support from important family and friends.	• Link to website program • Telephone contacts • Social media
Somatic and Affective States	• Daily home-monitoring of blood pressure. • Regular tracking of blood cholesterol values. • Monitoring of emotional changes during blood pressure control at home. • Sharing experiences of blood pressure control at home	• Link to website program • Telephone contacts

Note: H-Scale, Hypertension Self-Care Activity Level Effects Scale.

in cardiovascular disease. The video included the following: learning how to personally measure blood pressure correctly, the meaning of the blood pressure values, how to prevent major complications of hypertension, how to select a healthy diet (including understanding nutrition facts and sodium calculations), how to control body weight, how to choose physical activities as well as exercises, and the effects of smoking and heavy drinking on blood pressure.

Website data entry

In the blood pressure values section, participants entered the setting for their optimal value for blood pressure and recorded their daily home blood pressure. This section contained a reminder function, which consisted of a pop-up window with guidance appropriate for their blood pressure. For example, if the SBP was over 180 mm Hg, the participant would receive an alert that this was too high, and the research team would receive an email notification. If the blood pressure values entered were within normal range, a pop-up window would confirm the values were normal and positive feedback would be provided, which encouraged the participant to maintain their behavioral changes. Participants could set up a daily, weekly, or monthly schedule to send blood pressure values to family members, allowing a collaborative approach for maintaining a healthy lifestyle and blood pressure control at home. A pop-up window would also appear on the website each day to remind the participant to take their antihypertensive medication.

Measurements

Baseline measures included socio-demographic and clinical characteristics collected with a research-designed survey questionnaire, which consisted of age, gender, marital status, living status, education, work status, smoking habits, BMI, duration of having hypertension, comorbidities, serum creatinine levels, and defined daily dose of antihypertensive medications (WHO, 2009). Measures on two self-report instruments and risk indicators of cardiovascular events (described below) were used as outcome measures.

Risk indicators of cardiovascular events

Risk indicators of cardiovascular events were estimated by pulse pressure (PP) (mm Hg), triglycerides (mg/dl), LDL-C, and HDL-C (mg/dl). The cut-off point for the PP was calculated based on hypertension guidelines established in 2015 for the adult population in Taiwan (SBP < 120 mm Hg and DBP < 80 mm Hg) to define optimal blood pressure values, which was defined as <40 mm Hg in this study (Chiang et al., 2015). Vascular stiffening can cause increased PP, which increases the risk of cerebrocardiovascular disease and a worse prognosis (Franklin et al., 2015; Tang et al., 2020). The levels for triglycerides, LDL-C, and HDL-C, were based on the 2017 lipid guidelines for Taiwan and a recent study (Li et al., 2017), which demonstrate a triglyceride level < 150 mg/dl, an LDL-C level < 100 mg/dl, and an HDL-C level ≥ 40 mg/dl are indicators that lipid concentrations are well controlled, and that

the risk of cerebrocardiovascular diseases is low, even for patients at-risk for cardiovascular events.

Self-efficacy for managing chronic disease

The Chinese version of the Self-Efficacy for Managing Chronic Disease 6-Item Scale (SEM6C) was used to measure participants' self-efficacy, which has been widely used to measure self-management in patients with chronic diseases (Hu et al., 2015; Wang et al., 2017). Each item is scored from 1 to 10, with 1 = "not confident all" and 10 = "very confident" for a total score between 6 and 60 (Lorig et al., 2001). The Chinese version of the SEM6C has a Cronbach's α of 0.88 and was assessed for concurrent validity using the Hospital Anxiety and Depression Scale (HADS) with the overall score $r = -0.30$; $p < 0.001$, thus indicating that the Chinese version of SEM6C has good reliability and validity (Hu et al., 2013). The Cronbach's α for the SEM6C in our study was 0.85.

The hypertension self-care activity level effects scale

The Hypertension Self-Care Activity Level Effects Scale (H-SCALE) was used to measure participants' self-care behaviors in their daily lives (Warren-Findlow & Seymour, 2011). The H-SCALE was developed based on the Seventh Joint Committee on Hypertension guidelines, which recommends a healthy lifestyle using 33 items covering dimensions of adherence to medications, diet, prescribed physical activity, appropriate weight management, and avoidance of tobacco and harmful levels of alcohol consumption. The H-SCALE is comprised of six subscales with questions about a patient's self-care behavior. The internal consistency across the six subscales of the original scale ranged from 0.77 to 0.93 (Warren-Findlow et al., 2013).

Medication adherence subscale (3 items) assesses frequency that medications were taken on time, and frequency of the correct dose over the last 7 days. Total scores range from 0 to 21; a score of 21 or ≥80% of medications taken in the past week indicates good adherence.

The DASH-quality subscale (11 items) asks how many of 11 target nutrients were consumed in the previous 7 days. The total score ranges from 0 to 77 points: ≤32 points = low quality diet; 33–51 points = moderate quality diet; and ≥52 points = good adherence.

Physical activity subscale (2 items). Two questions ask whether the individual engaged in physical activities or other exercises for a period ≥30 min per day in the previous 7 days. Scores range from 0 to 14, which a score ≥ 8 considered good adherence to suggested physical activity.

The weight management subscale (10 items) asks if the participant believes they have achieved proper weight management through diet or physical activity in the past month. Each item is scored from 1 (strongly disagree) to 5 (strongly agree). The total score ranges from 10 to 50; higher scores indicate better weight management and a score ≥ 40 indicates good weight management.

The tobacco exposure subscale (2 items) assesses whether a participant smoked or was exposed to secondhand smoke in the previous 7 days. Items were scored 0 = no or 1 = yes. Complete abstinence was required to respond "no". A score of "0" indicated good adherence.

The alcohol intake subscale (3 items). Participants were asked three questions about alcohol consumption in the previous 7 days. The first question asks if alcohol was consumed in the previous 7 days. If the answer is yes, the second and third questions ask about amount and type of alcohol consumed. No alcohol consumption was required for good adherence.

After obtaining authorization from the authors of the H-SCALE, we translated the scale into Chinese using forward-translation through an English-language speaker fluent in Taiwanese followed by back-translations through a native Taiwanese researcher fluent in English. To retain consistency for foods not common in Taiwan, such as pickled olives and collard greens, we substituted Taiwanese pickles and other high-potassium vegetables, such as sweet potato leaves or water spinach. Next, we invited five cardiovascular disease experts to review the Chinese version of the H-SCALE and revised it based on their suggestions. Finally, 20 patients with primary hypertension were asked to complete the Chinese version scale and provide feedback as to whether any questions for difficult to understand. After the pilot study, we removed questions 32 and 33 because most participants were unable to answer them accurately, and asked "How many days during the previous week did you drink alcohol?" In our study, the range of Cronbach's α for the subscales ranged from 0.71 to 0.93; the content validity index for the subscales ranged from 0.90 to 0.95.

Data collection

All patients received standard care, which included a pamphlet on managing common hypertension, consultations suggesting lifestyle modifications, blood pressure checks, and routine follow-up treatments for medication. The intervention group received training with the web-based self-care program for 1 month. At baseline, all participants received a calibrated personal sphygmomanometer; the circumference of the blood pressure cuff was sized for each participant. Participants were given instructions on proper placement of the cuff on the upper arm and how to measure blood pressure. All participants recorded their baseline blood pressure values and completed the survey questionnaire on socio-demographic and clinical characteristics. The Chinese version of the SEM6SC and the H-SCALE were completed by both groups at baseline and follow-up at 3-months and 6-months. Pulse pressures were calculated through participants recording their home blood pressure values and follow-up at 3-months and 6-months. All blood lipid values in both groups were obtained from chart review of the patient medical records at baseline and 6-months.

Data analysis

Data were analyzed by IBM SPSS, version 21.0 (IBM Corp). Socio-demographic and clinical characteristics were presented as the mean and standard deviation (SD) for continuous variables and frequency and percentage for categorical variables. The primary outcome measure was the change in PP from baseline to 3- and 6-month follow-up. Secondary outcomes were levels of TG, LDL-C, HDL-C, scale scores for self-efficacy and self-care abilities at 3- and 6-month follow-up compared with baseline measures. The homogeneity of the socio-demographic and clinical characteristics between the two groups was examined using independent t-tests and chi-square tests. Generalized estimating equations (GEE) determine the differences in outcome measures between the two groups at baseline (T0), 3-month follow-up (T1), and 6-month follow-up (T2) based on the intention-to-treat principle.

RESULTS

Baseline socio-demographic and clinical characteristics

The socio-demographic and clinical characteristics of the 222 participants are presented in Table 2. The mean age of the participants was 62.7 ± 9.3 years and 51.35% were males. Most participants were married (93.69%), lived with their families (94.1%) and were non-smokers (87.4%). Clinical characteristics included a mean BMI of 26.44 kg/m^2 (SD = 3.79) with 49.1% having been diagnosed with hypertension for more than 5 years. The mean serum creatinine level was 0.83 mg/dl (SD = 0.17), and the most common comorbidities were hyperlipidemia (47.3%) and diabetes (38.29%). The overall antihypertensive defined daily dose was 1.80 units (SD = 1.00). Only the demographic of educational level differed significantly between participants in the intervention and control group ($p < 0.05$); there were no differences in baseline clinical characteristics between groups.

Baseline risk indicators of cardiovascular events, self-efficacy, and self-care

None of the cardiovascular risk indicators at baseline differed between the two groups. The mean PP was 63 mm Hg (SD = 11.31) and 62 mm Hg (SD = 12.26) for the intervention and control groups, respectively. Both groups had high serum levels of LDL-C and borderline levels of triglycerides (Table 3).

Mean baseline scores on the SEM6C were significantly higher for the control group (35.31 ± 8.45) compared with the intervention group (32.0 ± 9.76. $p < 0.05$), however scores indicated both groups had a medium level of self-efficacy. None of the subscale scores on the H-SCALE differed between groups at baseline. Participants in both groups had moderate quality diet, and all five other subscale scores were low. (Table 3).

Effect of the web-based self-care intervention on risk indicators of cardiovascular events

The GEE model examined the effect of the intervention on PP at T1 and T2 after adjusting for significant differences between groups at baseline (Table 4; Figure S1). The intervention group had a significantly greater decrease in PP compared with the control group at T1 ($\beta = -17.37$, $p < 0.001$) and T2 ($\beta = -20.30$, $p < 0.001$). Compared with the control group, the intervention group also had significant decreases on serum triglycerides and LDL-C at T2 ($\beta = -27.69$, $p < 0.05$ and $\beta = -13.05$, $p < 0.01$, respectively). Serum HDL-C levels increased significantly in the intervention group compared with the control group at T2 ($\beta = 5.27$, $p < 0.01$). These results suggest the web-based self-care program helped participants reduce their risk of cardiovascular events.

Effect of the web-based self-care intervention on self-efficacy and self-care

The effect of the web-based self-care program on self-efficacy and self-care were examined by GEE analysis (Table 4; Figure S2, S3). After adjusting for differences between groups at baseline, the GEE model showed the mean scores on the SEMC6 increased significantly more in the intervention group compared with the control group at T1($\beta = 14.54$, $p < 0.001$) and T2 ($\beta = 21.84$, $p < 0.001$), suggesting the web-based self-care program improved participants' self-efficacy compared with usual care.

There was a significantly greater increase at T1 and T2 in mean scores for four of the subscales of the H-SCALE (medication adherence, DASH diet, weight management, and physical activity) in the intervention group compared with the control group (all $p < 0.001$). Neither tobacco exposure nor alcohol intake differed between groups. These findings suggest participants who received the web-based self-care program improved adherence to medication, the DASH diet, weight control, and physical activity compared with participants who received no additional support.

DISCUSSION

This randomized controlled trial was novel in that it demonstrated a theoretically based self-care program with a web-based approach could effectively help patients with primary hypertension control their blood pressure. The main findings of our research demonstrated that the web-based self-care program significantly reduced risk factors for cardiovascular events (PP and lipids), increased self-efficacy, and improved self-care behaviors (medication adherence and healthy lifestyle) at 3- and 6-months follow-up compared to baseline measures. These improvements were also significantly better at both two time points compared with patients in the control group who received usual care. The intervention group had the most significant improvement in the

TABLE 2 Baseline patient demographic and clinical characteristics for all participants and differences between the intervention and control groups

Characteristic	Overall (*N* = 222)	Intervention (*n* = 111)	Control (*n* = 111)	t/X^2	*p*
Age, years, mean ± SD	62.7 ± 9.3	62.07 ± 9.77	63.40 ± 8.80	−1.06	0.29
Gender *n* (%)				0.07	0.89
Female	108 (48.6)	55 (49.5)	53 (47.7)		
Male	114 (51.4)	56 (50.5)	58 (52.3)		
Marital status, *n* (%)				2.75	0.17
Single/Divorce	14 (6.3)	4 (3.6)	10 (9.1)		
Married	208 (93.7)	107 (96.4)	101 (90.9)		
Educational level, *n* (%)				27.02	**0.01**
≤6th grade	59 (26.6)	14 (12.6)	45 (40.5)		
7th–12th grade	79 (35.6)	40 (36.0)	39 (35.2)		
>12th grade	84 (37.8)	57 (51.4)	27 (24.3)		
Residence, *n* (%)				0.74	0.57
Live alone	13 (5.9)	5 (4.50)	8 (7.21)		
Live with family/others	209 (94.1)	106 (95.50)	103 (92.79)		
Smoking status, *n* (%)				0.16	0.84
Yes	28 (12.6)	15 (13.5)	13 (11.7)		
No	194 (87.4)	96 (86.5)	98 (88.3)		
Body mass index, mean ± SD	26.44 ± 3.80	26.38 ± 3.73	26.50 ± 3.87	−0.23	0.82
Duration of hypertension, *n* (%)				3.74	0.15
<1 year	27 (12.2)	18 (16.2)	9 (8.1)		
1–5 years	86 (38.7)	43 (38.7)	43 (38.7)		
>5 years	109 (49.1)	50 (45.1)	59 (53.2)		
Creatinine (mg/dl), mean ± SD	0.83 ± 0.17	0.81 ± 0.15	0.85 ± 0.18	−1.50	0.14
Comorbidity, *n* (%)					
Hyperlipidemia	105 (47.30)	50 (45.0)	55 (49.5)	0.45	0.50
Diabetes	85 (38.29)	40 (36.0)	45 (40.5)	0.48	0.49
Gout	23 (10.36)	9 (8.1)	14 (12.6)	1.21	0.27
Coronary artery disease	41 (18.57)	17 (15.3)	24 (21.6)	1.47	0.23
Overall antihypertensive, mean ± SD					
Defined daily dose	1.80 ± 1.00	1.68 ± 0.85	1.92 ± 1.14	0.71	0.48

Abbreviation: SD, standard deviation.

lifestyle dimensions of diet and weight management compared with the control group, suggesting the tailored counseling provided by the web-based self-care program was effective in helping patients achieve behavior change in dietary adherence and weight management.

Baseline characteristics of the participants

The mean age of the participants and percent of individuals diagnosed with hypertension for more than 5 years (62.7 years and 49.1%, respectively) is consistent with previous epidemiological data on hypertension in Taiwan (Chiang et al., 2015; Ministry of Health and Welfare, 2021). The main comorbidities of participants were hyperlipidemia and diabetes mellitus, both of which can increase the likelihood of future vascular endothelial damage, vascular stiffness, and aggravation of damage to target organs damage for patients with cardiovascular diseases.

Baseline characteristics between the two groups differed for two variables. Compared with the control group, the participants in the intervention group had significantly higher level of education, while lower level of confidence in self-efficacy for managing chronic disease. Our findings differ from a study by Hu et al. (2015) demonstrating people with a higher educational level have more confidence in their blood pressure control. One explanation for these differences may be owing to the concern of the participants in the

TABLE 3 Baseline scores for variables of self-management performance for all participants and differences between the intervention and control groups

Variables	Overall (*N* = 222) Mean ± SD	Intervention (*n* = 111) Mean ± SD	Control (*n* = 111) Mean ± SD	t	*p*
Cardiovascular risk indicators					
Pulse pressure (mm Hg)	63.05 ± 11.77	63.16 ± 11.31	62.95 ± 12.26	0.14	0.89
Triglycerides (mg/dl)	144.74 ± 87.28	141.98 ± 80.96	147.50 ± 93.60	−0.47	0.64
LDL-C (mg/dl)	108.34 ± 30.73	109.84 ± 26.33	106.83 ± 35.12	0.72	0.47
HDL-C (mg/dl)	48.62 ± 12.27	50.08 ± 14.12	47.15 ± 10.42	1.76	0.08
Self-efficacy					
SEMC6 scale	33.66 ± 9.11	32.0 ± 9.76	35.31 ± 8.45	−2.70	0.01
Self-care					
H-SCALE subscales					
Medication	15.49 ± 5.71	15.68 ± 5.35	15.29 ± 6.07	0.51	0.61
DASH diet	37.05 ± 12.67	38.22 ± 13.51	35.87 ± 11.82	1.38	0.17
Weight management	25.77 ± 6.91	24.42 ± 7.30	24.70 ± 6.51	−0.30	0.76
Physical activity	7.42 ± 4.01	7.43 ± 4.10	7.41 ± 3.92	0.03	0.97
Tobacco exposure	1.02 ± 2.84	1.15 ± 3.27	0.89 ± 2.40	0.68	0.50
Alcohol intake	0.33 ± 1.32	0.32 ± 1.30	0.34 ± 1.34	−0.15	0.88

Abbreviations: DASH, Dietary Approaches to Stop Hypertension; HDL-C, High-density lipoproteins-cholesterol; H-SCALE, Hypertension Self-Care Activity Level Effects; LDL-C, Low-density lipoproteins-cholesterol; SEMC6, 6-item Self-Efficacy of Managing Chronic Diseases Scale.

intervention group about complications from hypertension; after search for information online, participants worried they might not be able to avoid having strokes even when their hypertension was well-controlled. Therefore, we used GEE to evaluate the effectiveness of this program after adjusting for these differences at baseline.

Baseline self-efficacy scores for participants had a medium level; suboptimal self-care scores were reported; and LDL-C and PP values were high. Although many participants in our study had hyperlipidemia (47.3%), they refused to take hypolipidemic agents because there were counterfeit medications circulating in Taiwan at the time, which impacted their confidence with the medicine. This baseline data serves as evidence that participants urgently needed a suitable self-care program to control their blood pressure and improve related risk factors.

Effects of the web-based self-care program on cardiovascular risk indicators

Measures of cardiovascular risk improved across all indicators, which is consistent with a previous study using internet-based intervention to improve hypertension management and resulting in decreased PP, lower serum triglycerides and LDL-C, and increased HDL-C at 6 months (Nolan et al., 2018). In addition, this web-based self-care program enhanced participants' confidence in modifying their lifestyles, which may have contributed to reductions in these cardiovascular risk factors.

Effect of the web-based self-care program on self-efficacy

Our results demonstrating participants in the web-based self-care program had significant improvements in self-efficacy and self-care strengthen previous findings showing individualized health education intervention has been demonstrated to be beneficial for enhancing self-efficacy of achieving blood pressure control (Van Truong et al., 2021).

In addition, we applied the four components of self-efficacy theory to enhance their self-efficacy. First, we used three strategies to assist them to achieve better "enactive attainment" and enhance their confidence as well as sustain mastery of behaviors: (1) linking past experiences with new knowledge to increase confidence; (2) goal setting to motivate establishment of new behaviors; and (3) reinforcing what was learned via the website, which reduced the burden of having to remember a large amount of new information in a short time. The website also included alerts and immediate feedback, which further enhanced confidence and sustained mastery of behaviors. Our findings add to the literature on the use of technology for supporting changes in behaviors (Li et al., 2020; Nolan et al., 2018; Tam et al., 2020).

Vicarious experiences comprised the second component of self-efficacy theory, which was applied by including an anonymous message board for sharing experiences among participants about home blood pressure control. The third component, verbal persuasion, was provided through immediate advice and encouragement

TABLE 4 General estimating equation analysis for the effect of the intervention on pulse pressure, serum lipids, self-efficacy and self-care ($N = 222$)

Outcomes	β coefficient	SE	95% CI	χ^a	*p*
Cardiovascular risk indicators					
Pulse pressure (mm Hg)					
Group[b]	0.22	1.56	−2.85, 3.28	0.02	0.89
Time[a]					
3-months	3.56	0.99	1.62, 5.50	12.95	<0.001
6-months	5.03	1.25	2.58, 7.48	16.15	<0.001
Group[b] × Time[a]					
3-months	−17.37	1.40	−20.11, −14.63	154.27	<0.001
6-months	−20.30	1.77	−23.76, −16.83	131.67	<0.001
Triglycerides (mg/dl)					
Group[b]	−5.51	11.69	−28.43, 17.41	0.22	0.64
Time[a]					
6-months	16.32	8.77	−0.87,33.50	3.46	0.06
Group[b] × Time[a]					
6-months	−27.69	12.57	−52.33, −3.06	4.86	0.03
LDL-C (mg/dl)					
Group[b]	3.01	4.15	−5.12,11.14	0.53	0.47
Time[a]					
6-months	3.12	2.78	−2.34, 8.57	1.25	0.26
Group[b] × Time[a]					
6-months	−13.05	4.29	−21.44, −4.65	9.27	0.002
HDL-C (mg/dl)					
Group[b]	2.93	1.66	−0.32, 6.18	3.12	0.08
Time[a]					
6-months	−2.25	0.80	−3.82, −0.69	7.98	0.01
Group[b] × Time[a]					
6-months	5.27	1.66	2.02, 8.52	10.12	0.001
Self-efficacy					
SEMC6 scale					
Group[b]	−3.31	1.22	−5.67, −0.92	7.35	0.007
Time[a]					
3-months (T1)	−4.74	0.83	−6.37, −3.11	32.35	<0.001
6-months (T2)	−6.58	0.84	−8.22, −4.92	61.79	<0.001
Group[b] × Time[a]					
3-months	14.54	1.11	12.37, 16.71	172.34	<0.001
6-months	21.84	1.32	19.25, 24.42	274.28	<0.001
Self-care					
H-SCALE subscales					
Medication adherence					
Group[b]	0.61	0.80	−0.95, 2.18	0.59	0.44
Time[a]					
3-months	−0.27	0.55	−1.35, 0.81	0.24	0.62
6-months	−0.01	0.55	−1.17, 0.97	0.33	0.86
Group[b] × Time[a]					
3-months	3.79	0.72	2.38, 5.21	27.61	<0.001
6-months	4.75	0.76	3.26, 6.23	39.34	<0.001
DASH diet					
Group[b]	1.36	1.76	−2.09, 4.81	0.60	0.44

TABLE 4 (Continued)

Outcomes	β coefficient	SE	95% CI	χ^{a}	*p*
Time[a]					
3-months	−3.97	1.03	−5.99, −1.95	14.85	<0.001
6-months	−4.69	1.21	−7.07, −2.31	14.88	<0.001
Group[b] × Time[a]					
3-months	17.21	1.52	14.23, 20.19	128.25	<0.001
6-months	22.49	1.926	18.71, 26.26	136.33	<0.001
Weight management					
Group[b]	−0.38	0.97	−2.28, 1.51	0.16	0.69
Time[a]					
3-months (T1)	−1.83	0.55	−2.90, −0.76	11.16	0.001
6-months (T2)	−1.85	0.63	−3.07, −0.62	8.73	0.003
Group[b] × Time[a]					
3-months	14.57	0.80	13.01, 16.12	334.91	<0.001
6-months	18.98	0.96	17.10, 20.87	389.99	<0.001
Physical activity					
Group[b]	−0.16	0.57	−1.27, 0.95	0.08	0.78
Time[a]					
3-months	−0.64	0.31	−1.25, −0.03	4.27	0.04
6-months	−0.87	0.32	−1.51, −0.24	7.36	0.01
Group[b] × Time[a]					
3-months	3.11	0.47	2.18, 4.03	43.29	<0.001
6-months	4.26	0.54	3.21, 5.31	63.23	<0.001
Tobacco exposure					
Group[b]	0.13	0.43	−0.72, 0.97	0.09	0.76
Time[a]					
3-months	−0.23	0.21	−0.64, 0.17	1.29	0.26
6-months	−0.05	0.21	−0.47, 0.36	0.07	0.80
Group[b] × Time[a]					
3-months	−0.56	0.33	−1.21, 0.09	2.85	0.09
6-months	−0.75	0.38	−1.50, 0.001	3.83	0.05
Alcohol intake					
Group[b]	−0.06	0.20	−0.44, 0.32	0.097	0.76
Time[a]					
3-months	−0.18	0.11	−0.39, 0.03	2.85	0.09
6-months	−0.13	0.10	−0.33, 0.07	1.53	0.22
Group[b] × Time[a]					
3-months	−0.05	0.14	−0.33, 0.23	0.14	0.71
6-months	−0.11	0.16	−0.42, 0.20	0.47	0.49

Abbreviations: CI, confidence interval (lower, upper); DASH, Dietary Approaches to Stop Hypertension; HDL-C, High-density lipoproteins-cholesterol; H-SCALE, Hypertension Self-Care Activity Level Effects scale; LDL-C, Low-density lipoproteins- cholesterol; SEMC6, 6-item Self-Efficacy for Managing Chronic Diseases scale.

[a]Reference = baseline.

[b]Reference = control group.

from nurse clinician-researchers about lifestyle modifications to strengthen their recognition of new behaviors. The fourth component was somatic and affective states. When blood pressure values were close to reaching a participant's established goals, the website included a notification. This information increased confidence in their ability to alter their self-care behavior, which established a cycle of positive feedback and increased confidence.

Effects of the web-based self-care program on self-care

The effect of self-efficacy on medication adherence for participants in the intervention group echo the results of a meta-analysis of 12 randomized controlled trials by Van Truong et al. (2021), which showed self-care management programs facilitate medication adherence for older adults with hypertension. Sevick et al. (2018)

suggested the challenge of changing a person's lifestyle is to construct new knowledge and skills in such a way that barriers can be overcome without too much effort. The significant improvements in medication adherence for the intervention group compared with the control group may have been due to the medication reminder system on the website as well as the design of building new habits on established lifestyle behaviors, which may have also facilitated lifestyle changes.

Dietary behaviors also improved, which might be attributed to recommending the DASH diet, offering educational material on nutrition, and providing individualized dietary suggestions based on each participant's dietary assessment. One of the most frequent questions asked by participants was how to choose foods during special holidays while retaining dietary restrictions, suggesting the program had a significant impact on improving dietary behaviors. The significant improvement in dietary habits as well as physical activity in the intervention group at 3- and 6-months follow-up, compared with the control group, is reflected in the improvements in weight management, suggesting adjustments to diet, and increased physical activity can facilitate control of body weight.

While scores for smoking and alcohol consumption in the intervention group decreased over time, they did not reach statistical significance, which is consistent with the findings of Ayodapo and Olukokun (2019). Although there were only a few smokers in our study, most were long-term chain smokers, which is difficult behavior to change. We suggested these individuals to smoking cessation outpatient clinics for assistance. Although we can only speculate on why there was a lack of significant reduction in the levels of alcohol consumption, one reason may be due to cultural expectations in Taiwan. Traditional Chinese festivals as well as family celebrations of birthdays or weddings require drinking alcoholic beverages as a sign of respect (Tang et al., 2013). Further studies might consider including qualitative feedback regarding behavior changes.

Study limitations

One limitation of the study is the short follow-up time, which was due to insufficient funding and manpower. Therefore, a longer follow-up period is suggested to strengthen these findings. Second, the results of our research showed triglycerides and LDL-C were reduced at 6-months, but the long-term benefits of reducing cerebrocardiovascular disease risk will require verification. Third, to ensure that the participants were able to use the web-based program easily and correctly, we conducted face-to-face instructions and return demonstration. We reviewed their understanding of the program through a phone call or outpatient visit. However, some young participants expressed it was inconvenient to operate the web page. In the clinical practice or future study, if having sufficient funds, we recommend providing both the web-based program and a smartphone application (APP) to offer more convenience for those younger patients. Finally, we only included participants with primary hypertension from a single medical center, which limits the generalizability of the results.

CONCLUSIONS

Our findings suggest the combination of technology and self-efficacy theory through our web-based self-care program could be effective for enhancing self-efficacy, self-care, and reducing risks of cardiovascular events for patients with primary hypertension. This program also provided new knowledge, motivated the participants to modify their lifestyle, and offered immediate feedback based on their needs, which enabled the establishment and internalization of new behaviors over time. Given the growing demand for telemedicine and the increasing prevalence of hypertension, we recommend adopting this program as standard care for patients with hypertension.

CLINICAL RESOURCES

- Ministry of Health and Welfare. https://www. mohw.gov.tw/lp-5256-2.html
- World Health Organization. https://www.whocc.no /ddd/ definition_ and_ general _ considera/

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ORCID

Chi-Wen Kao https://orcid.org/0000-0003-4003-7564

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