ORIGINAL RESEARCH

The Effects of Stepping Exercise on Blood Pressure, Physical Performance, and Quality of Life in Female Older Adults with Stage 1 Hypertension: a Randomized Controlled Trial

Chawin Sarinukul, MSc[1], Taweesak Janyacharoen, PhD[1,2], Wanida Donpunha, PhD[1], Saowanee Nakmareong, PhD[1], Wanida Ruksapukdee, PT[3], Kittisak Sawanyawisuth, MD, PhD[4]

[1]School of Physiotherapy, Faculty of Associated Medical Sciences, Khon Kaen University, Khon Kaen; [2]Research Center in Back, Neck and Other Joint Pain and Human Performance, Khon Kaen University, Khon Kaen; [3]Department of Physiotherapy, Chum-Phae Hospital; [4]Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

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ABSTRACT

Background

Hypertension is a common disease, particularly in older adults. In a previous study, we found that an eight-week course of stepping exercise improved physical performance in healthy older adults as measured using the six-minute walk test (468 vs. 426 m in controls; $p = .01$). This study aims to further evaluate the effects of stepping exercise on blood pressure, physical performance, and quality of life in older adults with stage 1 hypertension.

Methods

This was a randomized, controlled trial comparing older adults with stage 1 hypertension who performed stepping exercise with controls. The stepping exercise (SE) was performed at moderate intensity three times/week over an eight-week period. Participants in the control group (CG) received verbal and written (pamphlet) lifestyle modification advice. Blood pressure at Week 8 was the primary outcome, while quality of life score and physical performance on the 6-minute walk test (6MWT), timed up and go test (TUGT), and five times sit to stand test (FTSST) were secondary outcomes.

Results

There were 17 female patients in each group (total of 34). After eight weeks of training, participants in the SE group showed significant improvements in systolic blood pressure (SBP; 132.0 vs. 145.1 mmHg; $p<.01$), diastolic blood pressure (DBP; 67.3 vs. 87.6 mmHg; $p<.01$), 6MWT (465.6 vs. 437.0; $p<.01$), TUGT (8.1 vs. 9.2 sec; $p<.01$), and FTSST (7.9 vs. 9.1 sec; $p<.01$) compared to controls. Regarding within-group comparison, participants in the SE also showed significant improvement in all outcomes from baseline, while any such outcomes in the CG were comparable from baseline (SBP: 144.1 to 145.1 mmHg; $p = .23$; DBP: 84.3 to 87.6 mmHg; $p = .90$).

Conclusions

The stepping exercise examined is an effective non-pharmacological intervention for blood pressure control in female older adults with stage 1 hypertension. This exercise also resulted in improvements in physical performance and quality of life.

Key words: physical performance, aging, hypertension, female

INTRODUCTION

Hypertension is a common condition associated with several cardiovascular diseases.[1] Its prevalence increases with age, particularly in those 65 or over.[2] Controlling blood pressure is one approach used to decrease hypertensive complications. Currently, there are two types of hypertension treatment: pharmacotherapeutic and non-pharmacotherapeutic, both of which are effective in blood pressure reduction.[3] The American College of Sports Medicine (ACSM) found strong evidence that physical activity leads to blood pressure reduction in adults with hypertension,[4,5] yielding reductions of systolic blood pressure (SBP) for 5–17 mmHg and diastolic blood pressure (DBP) for 2–10 mmHg. The ACSM recommends these patients engage in moderate- to high-intensity aerobic exercise most or all days of the week (> 40–60% of VO_2 reserve) for 30–60 minutes continuously with any bout duration.[5] Exercise is also a part of weight reduction which may result in better blood pressure control.[6–8]

Stepping is a type of aerobic exercise that results in oxygen consumption of 20.8–34.0 $ml \cdot kg^{-1} \cdot min^{-1}$ in young

healthy adults using a bench height of 21–31 cm.[9] In addition, a previous study found that stepping significantly improves functional ability and muscle volume in older adults,[10] with 10-meter walk test times significantly reduced from 6.3 to 5.7 sec ($p < .01$) and muscle volume increasing from 193 to 199 cm^3 ($p < .01$). In a previous study, we found that stepping exercise resulted in improved physical performance in healthy older adults.[11] After an eight-week course, participants attained significantly better scores on a six-minute walk test than controls (468 vs. 426 m; $p = .01$). This study aimed to evaluate if stepping exercise is beneficial in older adult patients with stage 1 hypertension as there is no previous study on this matter.

METHODS

Study Design and Participants

This was a randomized, controlled, open labeled trial to investigate the effects of stepping exercise on blood pressure, physical performance, and quality of life in the female older adults with stage 1 hypertension. The study was conducted at a club for older adults in Chum-Phae District in Khon Kaen, Thailand. The inclusion criteria were: 1) age 60–75 yrs; 2) diagnosis of stage 1 hypertension; 3) no medical contraindications for aerobic stepping exercise; 4) no physical exercise in the past two months; and 5) routinely taking medication for hypertension. Participants were excluded if they: 1) suffered from neurological impairment, severe cardiovascular disease, persistent joint pain, or musculoskeletal impairment; 2) had balance impairment due to adverse effects of medication; 3) had a visual analogue scale (VAS) score greater than 5 during intervention exercise; 4) were involved in any other exercise programs; or 5) engaged in regular smoking or alcohol consumption. Note that the VAS indicated tiredness while performing exercise; zero indicated no tiredness and 10 indicated the most tiredness. The study period was between January and March 2021. This study and the consent form were approved by the Khon Kaen University institutional review board (HE632220). Signed written informed consent was obtained from all subjects.

Intervention

The control group (CG) was given lifestyle modification advice based on recommendations by the American College of Cardiology and American Heart Association (ACC/AHA Blood Pressure Treatment Guideline: Lifestyle Modification and Drug Therapy) without specific exercise intervention. Participants were given lifestyle advice regarding weight control, proper diet, sodium consumption, alcohol reduction, and non-specific exercise for optimal blood pressure. Additionally, they received pamphlets detailing these recommendations.

The experimental group performed 60-minutes of stepping exercise (SE), three times/week for eight weeks as a group at 8:00 a.m. on the appointed day. The stepping exercise consisted of ascending and descending phases continuously over the bench. Each session consisted of three phases: warm-up (5 min), moderate-intensity stepping exercise (50 min), and cool-down (5 min). The bench height was set at about 20 centimeters. The target intensity was controlled by a metronome at a tempo of 100 beats/min. For the first two weeks, the stepping rate was set as tolerated for the participants. Then, the metronome rate was set for 90 and 100 beats/minute at the end of Week 2 and 4, respectively. Each session was supervised by a trained instructor who was experienced in stepping exercise. Participants' exercise schedule was set prior two starting the program, and they were reminded of the next scheduled date by the researchers at the end of each session. If the participants were unable to take part in any of the sessions, the researchers scheduled a make-up session so that they could complete the study protocol.

Measurements

At baseline, participants' baseline characteristics were measured including body mass index, waist-to-hip ratio, and grip strength. Body mass index was calculated by body weight (kg) divided by the square of height in meters, while waist-to-hip ratio was a proportion of the waist to the hip. Waist circumference was the midpoint between the last palpable rib and the top of the iliac crest, while the widest point of the buttocks was marked as the hip circumference. Hand grip strength was measured by the Jamar dynamometer and reported in kg. A calibrated digital sphygmomanometer from the medical instrument calibration unit was used to measure blood pressure. Measurements were taken three times at 2-min intervals early in the morning with the participant in a seated position after having rested for 10 min. The mean of each participant's SBP and DBP were recorded. Treatment of antihypertensive medications in each participant was also reported including angiotensin-converting-enzyme inhibitors (ACE inhibitors), calcium channel blockers, and diuretics.

Outcomes

The primary outcome of this study was blood pressure at Week 8 after intervention. Secondary outcomes included physical performance and quality of life scores.

Blood pressure was measured as stated in the baseline measurement. Physical performance parameters included cardiovascular endurance, lower leg strength, and balance ability, which were assessed using a 6-min walk test (6MWT) in meters, five times sit-to-stand test (FTSST) in sec, and timed up-and-go test (TUGT) in sec, respectively. The 6MWT, a test for cardiovascular endurance, measured the longest distance as possible by the participants in a square for six min. The FTSST procedure, a test for lower-limb strength, performed by sitting on a chair and asked to rise and sit as quickly as possible for five times. The TUGT, a test for mobility, evaluated by asking the participants to rise from a chair, walk for 3 meters, turn around, and return back to sit on a chair. Procedural details are described in our previous study.[11] Quality of life was assessed using the Thai version of the WHO QoL Questionnaire.[11,12]

The questionnaire comprised of 24 questions with five items rating scale. The total score of the questionnaire was 120 and categorized into three categories: low (24–55), fair (56–88), and high QoL (89–120).

Sample Size and Randomization

The sample size was calculated using systolic blood pressure as the main variable. As there had been no previous study examining the ability of stepping exercise to lower blood pressure, a study of aerobic resistance exercise in older adults with hypertension was used for sample size calculation.[13] The exercise group had a mean (SD) systolic blood pressure of 122.80 (9.90) mmHg, while the control group had mean (SD) of systolic blood pressure of 135.30 (12.10) mmHg. Based on a 0.05 α error and 0.2 β error and given a power of test of 80%, the required sample size was determined to be 13 patients in each group. With an estimated dropout rate of 30%, we determined that a total of 17 participants would be required in each group. Eligible participants were randomly allocated into the SE or CG with sealed envelopes which contained either the letter C or E (C for control group and E for experimental group).

Statistical Analysis

Baseline characteristics of participants in each group were calculated and compared using descriptive statistics. For numerical data, normally distributed data were presented as mean and SD, while non-normally distributed data were reported as mean and 1st–3rd interquartile range. Categorical data were presented as percentages. Data were presented in mean and standard deviation. A Shapiro-Wilk test was used for testing data distribution. To compare differences between the baseline and post-intervention within each group, a paired *t*-test or Wilcoxon signed-rank test were used for normally distributed and non-normally distributed data, respectively. The differences between groups in all outcomes were analyzed using the analysis of covariance (ANCOVA) or Kruskal-Wallis test for normally distributed and non-normally distributed data, respectively. Statistical significance was set at p value < .05. Data analyses were performed using SPSS version 22 (Chicago, Illinois, USA).

RESULTS

Subjects

A total 40 participants were recruited in the enrollment, six of whom were excluded due to not meeting the inclusion criteria, declining participation, or for other reasons. In total, 34 participants were enrolled and randomly allocated to the CG and SE (17 participants in each group). All participants were able to complete the study protocol.

Baseline Characteristics and Anthropometric Factors (Table 1)

All participants were female. Most variables were comparable between the two groups except age, waist–hip ratio, and diastolic blood pressure. The CG was younger, had a smaller waist–hip ratio, and had higher DBP than the SE (64.6 vs. 68.1 yrs, 0.9 vs. 0.9 and 83.7 vs. 79.2 mmHg). There were no significant differences between groups with regard to type of antihypertensive medication.

Outcome Variables

After eight weeks of training, the SE showed significant improvement in terms of SBP (132.0 vs. 145.1 mmHg; $p < .01$), DBP (67.3 vs. 87.6 mmHg; $p < .01$), 6MWT (465.6 vs. 437.0; $p < .01$), TUGT (8.1 vs. 9.2 sec; $p < .01$), and FTSST (7.9 vs. 9.1 sec; $p < .01$). In terms of within-group comparison, participants in the SE also showed significant improvement in all outcomes from baseline, while any such outcomes in the CG were comparable from baseline (SBP: 144.1 to 145.1 mmHg; $p = .23$; DBP: 84.3 to 87.6 mmHg; $p = .90$) (Table 2).

TABLE 1.
Baseline characteristics of participants categorized by treatment: control group (CG) or stepping exercise group (SE)[a]

Data/Group	*CG (n = 17)*	*SE (n = 17)*	*p value*
Age, years	64.6±3.6	68.1±3.4	0.01
BMI, kg/m^2	26.0±4.1	23.8±0.9	0.10
Waist-hip ratio	0.9±0.0	0.9±0.1	0.02
Handgrip strength, kg.	18.5±2.6	18.1±2.0	0.70
Systolic blood pressure, mmHg	144.1±5.6	147.3±4.3	0.60
Diastolic blood pressure, mmHg	83.7±8.0	79.2±5.0	0.07
Antihypertensive medications, n (%)			0.41[b]
ACE Inhibitors	9 (52.9%)	7 (41.2%)	
Calcium channel blockers	7 (41.2%)	10 (58.9%)	
Diuretics	1 (6.9%)	0	

[a]Values are Mean±SD unless indicated otherwise.
[b]Analyzed by Chi-square.
BMI = body mass index.

TABLE 2.
Comparison of outcome measurements between the control group or CG (n=17) and stepping exercise group or SE (n=17) at baseline and eight weeks post-intervention

Outcomes	*Group*	*Baseline*	*8 Weeks*	*Within-group Comparison*	*Difference Between Groups (8 Weeks)*
SBP, mmHg	CG	144.1±5.6	145.1±5.9	.23[a]	<.01[c]
	SE	147.3±4.3	132.0±6.9	<.01[a]	
DBP, mmHg	CG	84.3 (64.3- 95.7)	87.6 (63.3- 93.0)	.90[b]	<.01[d]
	SE	79.0 (70.3- 86.0)	67.3 (60.0- 84.6)	<.01[a]	
6MWT, m	CG	432.2±39.5	437.0±48.4	.28[a]	.04[c]
	SE	432.0±30.6	465.6±31.3	<.01[a]	
TUGT, s	CG	9.4 (8.0- 12.8)	9.2 (7.8- 13.2)	.60[b]	<.01[d]
	SE	8.6 (8.1- 10.3)	8.1 (7.2- 9.5)	<.01[b]	
FTSST, s	CG	9.0 (7.6- 12.9)	9.1 (7.3- 12.7)	.60[b]	<.01[d]
	SE	8.7 (8.1- 10.3)	7.9 (7.2-10.3)	<.01[b]	
QOL	CG	112 (100- 124)	115 (98- 127)	0.16[a]	.12[d]
	SE	108 (83- 117)	121 (107- 130)	<.01[b]	

Values are mean± SD or median (1st- 3rd interquartile range).
[a]Paired *t*-test for within group comparison.
[b]Wilcoxon Signed Rank test.
[c]One way ANCOVA test.
[d]Kruskal-Wallis test.
SBP = systolic blood pressure; DBP = diastolic blood pressure; 6MWT = six-minute walk test; TUG = Time up and Go test; FTSST = five time sit to stand test; QOL = quality of life.

DISCUSSION

This study showed that the eight-week course of stepping exercise significantly lowered SBP/DBP (95% CI of mean difference) by 13.1 (-17.6, -8.6)/14.8 (-20.3, -9.3) mmHg in female older adults with stage 1 hypertension compared to controls (Table 2). A previous meta-analysis found that aerobic exercise was able to reduce blood pressure by 16.66/6.43 mmHg after eight weeks of intervention.[14] Another study conducted in adult subjects with borderline hypertension examined walking/jogging on a treadmill[15] and found that blood pressure in the exercise group was 16/11 mmHg lower than controls after 12 weeks of intervention. The greater blood pressure reduction found in that study may have been due its inclusion of young adults with borderline hypertension and the fact that the exercise course lasted 12 weeks. However, this stepping exercise provided a clinically significant reduction in blood pressure, as the systolic blood pressure was reduced by more than 10 mmHg.[16]

Regarding physical performance, all outcomes (6MWT, FTSST, and TUGT) had significantly improved after eight weeks of stepping exercise when compared to controls (Table 2). These results differ from those of a previous study conducted in healthy older adults,[11] which did not find significant improvement on the FTSST after an eight-week intervention. This difference may be explained by differences in baseline FTSST. In the previous study, baseline FTSST was 6.59 sec compared to 8.9 sec in our population, which may have resulted in differences being non-significant. However, other studies have confirmed that aerobic exercise significantly improves these physical performance parameters.[17,18] Our results may imply that stepping exercise is not only able to lower blood pressure, but also improves physical performance as measured using the 6MWT, TUGT, and FTSST in older adults with stage 1 hypertension.[11] Not surprisingly, quality of life also improved in the SE. However, the differences between groups were not significant.

There were some limitations. First, DBP and TUGT at baseline were significantly different between the two groups despite randomization. However, both outcomes differed significantly at eight weeks, both between groups and within the SE. Second, though we intended to enroll both sexes, only female patients participated in this study similar to most other studies in which a majority of those who participate in and complete the exercise program tend to be women.[9,11,17] These findings may indicate preference or selection of exercise and gender basis. Some factors related to hypertension were not studied, such as albuminuria or sleep apnea.[19–25] Finally, the results of this study may be specific to stepping exercise[26–28] and applicable only to patients with stage 1 hypertension treated with anti-hypertensive medications. Those with newly diagnosed hypertension without any symptoms or complications may use this exercise to lower blood pressure prior to treatment with medication. Further studies are required to prove this hypothesis, as are studies in older males.

The stepping exercise examined in this study is an effective non-pharmacological intervention for blood pressure control in female older adults with stage 1 hypertension.

Additional effects of this exercise include improvements in physical performance and quality of life.

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CONFLICT OF INTEREST DISCLOSURES

We have read and understood the *Canadian Geriatrics Journal*'s policy on conflicts of interest disclosure and the authors declare no conflicts of interest.

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Correspondence to: Kittisak Sawanyawisuth, md, phd, Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, 40002, Thailand
Email: kittisak@kku.ac.th