Original Article

# Acute Effects in Lowering Blood Pressure after Diaphragmatic and Slow Breathings in Treated Hypertensive Patients

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***Background***: Hypertension is one of the major risk factors for cardiovascular disease (CVD). Breathing exercise is an acceptable method for lowering the blood pressure (BP). However, little is known about the immediate effects of slow and diaphragmatic breathings in declining BP in hypertensive patients. In addition, a comparison between both techniques is unknown.

***Objective***: To compare acute effect in lowering BP between diaphragmatic breathing and slow breathing in treated hypertensive patients.

***Materials and Methods***: The present study was a quasi-experimental in 92 treated hypertensive subjects, divided into three groups, control (n = 29), slow breathing exercise (SBE) (n = 31), and diaphragmatic breathing exercise (DBE) (n = 32). All parameters of BP were recorded immediately and five minutes after SBE, DBE, and control groups. Data analyses were carried out by Two-way mixed ANOVA.

***Results***: When comparing to control, both breathing techniques could lower systolic BP. While there was no significant difference in pulse pressure (PP) after DBE, the lowering in PP appeared immediately after slow breathing.

***Conclusion***: Slow breathing had a higher efficacy in immediate lowering BP than diaphragmatic breathing in treated hypertensive patients.

***Keywords***: Hypertension, Slow breathing, Diaphragmatic breathing, Systolic blood pressure, Pulse pressure

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The prevalence of hypertensive patients mortality rate is 1.5 million per year in South-East Asia[1,2]. The prevalence of hypertension was around 21% among 2009 population in Thailand[3] and 22% among middle and elderly people in Ban Paew district[4]. Hypertension could lead to target organs damage, such as myocardial infarction, stroke, heart failure, chronic kidney disease, or death[5,6]. To control hypertension, it is important to prevent and/or decrease target organs damage.

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The treatments of hypertension including lifestyle modification, pharmacological, and non-pharmacological intervention have been used worldwide. Treatment of hypertension with anti-hypertensive drugs are effective but have side-effects such as orthostatic hypotension leading to fall and fracture in elderly hypertensive patients[6]. Lifestyle modification has been recommended to prevent and treat hypertension[7], such as salt restriction, control body weight, and exercise[8]. However, these modalities requires a need to change behavior, which is difficult for many patients.

Many studies reported the efficacy of breathing exercise in lowering blood pressure (BP). Most research emphasized on Yoga and device-guide, which is costly and time taking[9-11]. The benefit of device-guide (RESPeRATE) has been confirmed in several

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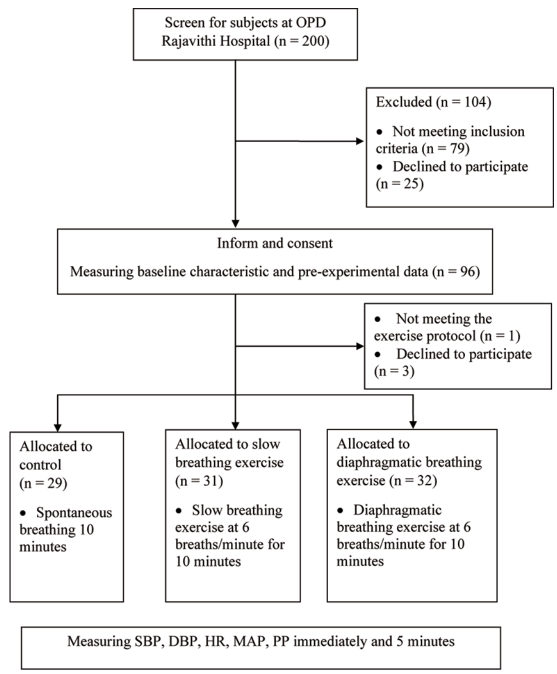


**Figure 1.** Flow of the subjects through the experiment.

clinical trial[12]. Slow breathing exercise (SBE) and diaphragmatic breathing exercise (DBE) might lower the BP[13]. However, few studies have documented the efficacy of these breathing techniques to lower the BP. A study compared efficacy of deep breathing at six breath per minute to 15 breath per minute. The result suggested that six breath per minute had greater effect on lower the BP through mechanism of improving baroreflex sensitivity[14]. Another study found mindful diaphragmatic breathing had higher heart rate (HR) variability than slow breathing at the same rate of six breath per minute[15]. Little is known about the acute effects of slow and diaphragmatic breathings in declining BP in hypertensive patients. Therefore, the present study was conducted to compare the effect between both techniques.

## Materials and Methods

### *Design*

Quasi-experimental design with single blind by participants was studied in Rajavithi Hospital. Hypertensive patients were recruited by a cardiologist from the Outpatients Department (OPD), Rajavithi Hospital, Bangkok, Thailand. The protocol was approved by the Ethics Committee of Rajavithi Hospital.

### *Participants*

Ninety-two hypertensive subjects aged 40 to 95 years were recruited by a cardiologist from the OPD Rajavithi Hospital. The subjects were divided into three groups, control (n = 29), SBE (n = 31), and DBE (n = 32) (Figure 1).

Inclusion criteria were:

1. Subjects were on the anti-hypertensive drugs for at least two months prior to initiation of the experiment.
2. Their BPs were in the range of 130 to 179 and/or 80 to 109 mmHg[16].
3. Good communication with cooperation and no device to support the body while walking.

Exclusion criteria were pregnancy, nursing mother, using hormone, steroids, chemotherapy, or the end stage of renal disease (ESRD).

Discontinuation criterion was not able to meet the breathing exercise protocol.

### *Procedure*

Hypertensive subjects were screened by a cardiologist. The measurements were collected at around 9 to 12 a.m. The researchers explained the purpose and procedure of the study to the subjects. Subjects refrained from breakfast and coffee or tea for at least two hours before the breathing exercise and agreed to sign the informed consents. Initially, baseline characteristic, including age, gender, body mass index, stress scale (Suan Prung Stress Test; SPST-20) from Department of Mental Health were also measured. BP including systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP), pulse pressure (PP), and HR, were measured as pre-experimental data. In control group, subjects were asked to sit and rest for 10 minutes in experimental room. In SBE, subjects were asked to deep breathe with inspiration for one to four seconds and expiration for one to six second within a minute and rest in a minute, at six cycles per minute for 10 minutes.

In DBE, subjects were asked to put the dominant hand on abdominal and non-dominant hand on the front upper chest. They were asked to breathe with abdominal deep inspiration for one to four seconds and expiration for one to six seconds within a minute and rest in a minute, at six cycles per minute for 10 minutes. All experimental subjects were to follow breathing exercise with the same instruction on the audio tape. One examiner monitored the efficacy of breathing during the exercise. Only subjects who kept their breathing according to all of the protocol would be included in the study. After completing the intervention, all subjects in the three groups measured

**Table 1.** Baseline characteristics of subjects

| Characteristics | Control (n = 29) Mean±SD | SBE (n = 31) Mean±SD | DBE (n = 32) Mean±SD | p-value |
|---|---|---|---|---|
| Age (years) | 70.9±10.9 | 67.0±8.83 | 66.1±11.9 | 0.18 |
| Weight (kg) | 69.0±13.2 | 66.7±12.2 | 64.3±10.4 | 0.31 |
| Height (m) | 1.62±0.08 | 1.59±0.09 | 1.59±0.1 | 0.34 |
| BMI (kg/m$^2$) | 26.4±4.44 | 26.5±5.12 | 25.3±3.6 | 0.49 |
| Stress score | 9.57±6.57 | 9.20±4.33 | 11.0±8.73 | 0.54 |
| Sex (male/female), n | 14/15 | 8/29 | 12/20 | |
| Active persons*, n | 17 | 21 | 22 | |
| Pre-experimental data | | | | |
| SBP (mmHg) | 135±16.6 | 139±17.1 | 134±16.5 | 0.46 |
| DBP (mmHg) | 76±11.2 | 79±10.9 | 80±9.2 | 0.31 |
| MAP (mmHg) | 95±10.8 | 99±11.5 | 98±10.3 | 0.34 |
| PP (mmHg) | 60±13.9 | 60 ±15.3 | 54±13.5 | 0.16 |
| HR (bpm) | 73±11.4 | 73±12.7 | 74±13.3 | 0.94 |

Data are mean±SD from number of subjects in the parenthesis without significant difference using one-way ANOVA

SBE=slow breathing exercise; DBE=diaphragmatic breathing exercise; SBP=systolic blood pressure; DBP=diastolic blood pressure; MAP=mean arterial pressure; PP=pulse pressure; HR=heart rate

* Active person defines as persons who exercise or have physical activity (>3 MET) at least 3 times per week

their BP including SBP, DBP, MAP, PP, and HR immediately and five minutes after the intervention.

### *Outcome measure*

All subjects recorded BP and HR by using automatic BP monitoring device (HEM-7221; OMRON), which had been calibrated. BP and HR was measured between 9.00 to 12.00 am after 10 minutes rest in sitting position. All parameters were recorded twice, with rest at least one minute in between measurements. If the difference of SBP or DBP between the two measurements was higher than 10/5, subjects were asked to rest at least one minute more and measured BP and HR again. All parameters were average to get a single value. While measuring BP and HR, subjects were asked to sit comfortably with feet on the floor. PP was calculated from the difference between systolic and diastolic pressure. MAP was calculated as DBP plus one-third of PP.

Subjects were asked to fill the stress questionnaire (Stress questionnaire-Suanprung version; ST-20) from the Department of Mental Health as a baseline characteristic. ST-20 divided the score into four categories, score 0 to 24 as mild stress, score 25 to 42 as moderate stress, score 43 to 62 as high stress, score of 63 or higher as severe stress.

### *Data analysis*

The result from the pilot study showed that the difference of SBP between both groups was –1.7 mmHg (SD 8.61). In order to achieve approximately 5% significant and 90% power, an estimated sample size of at least 29 per group or 87 subjects for the three groups should be recruited. In order to allow margin of error in cases of discontinuation, the sample size was increased to 96 in the present study.

Two-way mixed ANOVA with post hoc analysis (Turkey's test) were used to compare the changes in BP and HR between the control, SBE, and DBE after completing the study in 0 and 5 minutes. Statistical significance was taken as a p-value of less than 0.05. Statistical analyses were performed with IBM SPSS statistic 24.0.

## Results

### *Characteristics of participants*

All participants were between 40 and 95 years old, hypertensive patients treated with anti-hypertensive drug. In the experiment groups, all subjects could perform both slow and diaphragmatic breathing techniques for 10 minutes without any complications. Baseline characteristic and pre-experimental cardiovascular parameter revealed no significant difference among the three groups (p>0.05), as shown in Table 1. This indicated that baseline characteristic were similar.

### *Changes in blood pressure and heart rate after breathing*

To evaluate whether breathing technique could

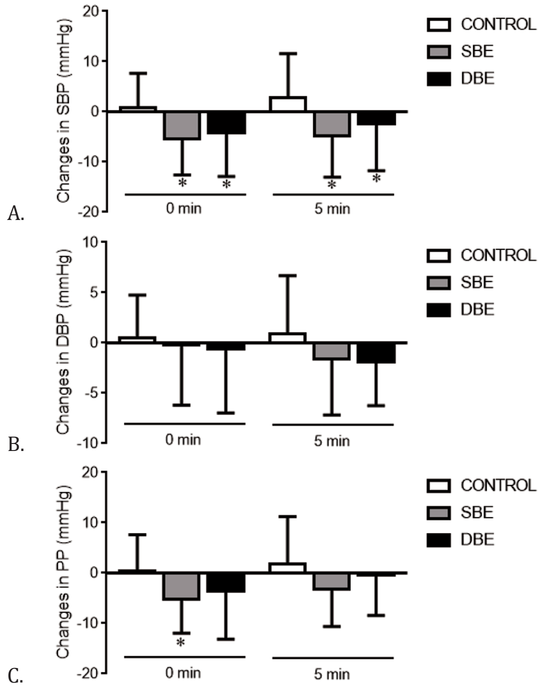


**Figure 2.** Comparison of (A) systolic blood pressure (B) diastolic blood pressure, and (C) pulse pressure between the groups.

Group and time effects were tested by two-way mixed ANOVA

SBE, slow breathing exercise; DBE, diaphragmatic breathing exercise; SBP, systolic blood pressure; DBP, diastolic blood pressure, PP, pulse pressure

* p<0.05 represents significant difference from control group

reduce the BP in hypertensive patients, hemodynamic changes after breathing were checked. From Figure 2, the control group maintained SBP immediately after and five minutes after spontaneous breathing (0.8±6.85 mmHg, 3±8.85 mmHg, respectively). In the SBE, the reduction of SBP was recorded immediately after and five minutes after the slow breathing exercise (–5±7.21 mmHg, –5±8.28 mmHg, respectively). The reduction of SBP was also recorded in the DBE group immediately after and five minutes after the breathing exercise (–4±8.75 mmHg, –2.4±9.35 mmHg, respectively). In addition, both SBE and DBE could significantly decrease the SBP comparing to control group (p=0.008, 0.043, respectively).

To further compare the efficiency in BP reduction between the two techniques, the other hemodynamic parameters were measured. While the DBP had been maintained in hypertensive patients comparing to the control group (p>0.05), PP was only significantly decrease after slow breathing (p=0.032). While the change in PP in control group was 0.3±7.30 mmHg, the change immediately after slow breathing was –5±6.77 mmHg. There was no change in HR and MAP after SBE and DBE (p>0.05).

## Discussion

In the present study, the authors evaluated the effect of breathing exercise on the changes in BP of hypertensive patients. Hemodynamic changes were recorded after DBE and SBE as compared to the control group. The results showed that both breathing techniques could reduce SBP, while DBP remains unchanged. Only slow breathing could decrease PP. The present result indicated the efficiency of both DBE and SBE in acutely lowering the BP in hypertensive subjects of the present study. In addition, SBE was more efficient to reduce the BP.

There are many beneficial effects to acutely lower the BP in hypertensive patients. A study of Lewington et al in 2002 showed the increase in SBP in middle and elderly age could induce cardiovascular risk(17). It implies that lowering SBP after breathing techniques in the present study could prevent further cardiovascular deterioration. Most elderly hypertensive patients have isolated systolic hypertension, while they maintain or reduce diastolic pressure by atherosclerosis of aorta. In the present study, the result showed the lowering in SBP without any changes in DBP indicates the safe protocol of both breathing techniques in elderly hypertension. The high SBP with low DBP was the cause of the wide PP. The wide PP was an indicator of cardiovascular risk in treated hypertensive patients(18). Thus, both slow and diaphragmatic breathing techniques are suitable to treat elderly hypertensive patients. Moreover, slow breathing exercise has superior effect by reduction of both SBP and PP.

There are possible mechanisms that explain the finding of the present study. Slow breathing at six cycles per minute enhance baroreflex, and chemoreflex sensitivity enhances parasympathetic arm and lower the BP(14). DBE correcting the breathing pattern could augment tidal volume, which stimulate Hering-Bruer reflex to reduce BP. However, the present study found SBE could reduce both SBP and PP. The finding may be explained by the elderly people who needed time to practice and correct the abdomen to do the diaphragmatic breathing. The difficult modality could enhance sympathetic arm.

The present study was limited in immediate effect of lowering BP. It remains to be questioned what are the long-term effects. Further studies are needed to assess and compare the effect of lowering BP between the two techniques. The present study measured office BP, which could not rule out the white coat effect.

## Conclusion

Simple SBE is another non-pharmacological treatment for immediate reduction of the BP in treated hypertensive patients.

## What is already known on this topic?

Previous study in reported breathing exercise, both SBE and DBE, shows that proper breathing can lower blood pressure in hypertensive patient.

## What this study adds?

This report compares SBE and DBE in lowering blood pressure. Both techniques reduce systolic blood pressure. However, only SBE has effect on lower PP. Therefore, this finding supports that SBE is more efficient to immediately reduce the blood pressure in treated hypertensive patients.

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## Conflicts of interest

The authors declare no conflict of interest.

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