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DIFFERENT BREATHING PATTERN AND ITS EFFECT ON AUTOMATED SYSTOLIC BLOOD PRESSURE (SBP) OF HEALTHY SUBJECTS

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ABSTRACT

Generally, deep breathing has been established to reduce blood pressure (BP).Besides, during inhalation BP is known to decrease while it increases during exhalation. To implement this idea to effectively and efficiently decrease BP, different breathing pattern involving differences in times of inhalation and exhalation could be very significant. This study will aim at quantitatively exploring the upshot of different breathing patterns on automated Systolic Blood Pressure (SBP). Forty healthy subjects that include 25 males and 15 females (aged between 18 to 60 years) were employed in this study. Automate SBP were measured using clinically authorized automated BP device. Two repeated measurement sessions was taken for each subject. For each session, eight BP measurements were obtained. The eight BP measurements involve: four measurements during breathing using different patterns (Pattern 1 to Pattern 4) (**Pattern 1**: (4.5s of inhalation and 4.5s of exhalation); **Pattern 2**: (6s of inhalation and 2s of exhalation); **Pattern 3**: (2s of inhalation and 6s of exhalation); **Pattern 4**: (1.5s of inhalation and 1.5s of exhalation), and another four measurements of the same measurement after a one-minute rest interval. Two baseline BP measurements exist under resting condition at the beginning and end of the two measurement sessions. Lastly, the effect of different breathing patterns on automated SBP during and after deep breathing was analysed in comparison with the automated baseline SBP. Experimental results showed that overall automated SBP measured during deep breathing in Patterns 1, 2 and 4 decreased significantly by 3.7 ± 5.7mmHg, 3.9 ± 5.2 mmHg and 3.3 ± 5.3 mmHg respectively (all $p < 0.001$)except for Pattern 3 where automated SBP decreased only by 1.7 ± 5.9 mmHg with p value ($p < 0.05$). Similarly, after deep breathing, automated SBP went back to normal with no significant difference when compared with baseline BP (all $p>0.05$, except for SBP in pattern 4 with a mean difference of 1.9±3.5 mmHg). In conclusion, a decrease in automated SBP with different breathing patterns has been quantitatively demonstrated with Pattern 2 being most effective, however slow and deep breathing (Pattern 3) inclines to be the best relaxed pattern for subjects to practice.

Keywords: breathing, Inhalation, Exhalation, breathing pattern, Systolic Blood Pressure

Introduction

Globally, High BP, also known as hypertension is known as the most common health problem (AHA, 2014).Hypertension, is established when BP readings are measured consistently for a number of weeks at 140 mmHg or above for SBP, and 90 mmHg or above for DBP. A single 140/90 mmHg reading at a particular time is not enough to conclude the diagnosis of high BP. More than two extra readings of such BP measurements are needed to be monitored over time. (Rolleston and Camb, 2007; Sharman et al., 2016).BP readings that persist consistently between (120/80) mmHg and (140/90) mmHg is known as Pre-high BP. Readings of 180/90 mmHg or higher indicates a hypertensive crisis (Petrie, et al., 1986; Fahey, Murphy and Hart, 2004; MacGregor and Kaplan, 2006; Sharman et al., 2016). Symptoms like severe headache, fatigue, confusion, problems associated with vision, chest pain, pounding in the chest, neck or ears, breathing difficulty and blood in urine could indicate the presence of extreme high BP. Persistent hypertension could lead to diseases like kidney failure, stroke or dementia, eye problems and heart disease (Rolleston and Camb, 2007).Hypertension can be treated by drugs like methyldopa, clonidine, labetalol, hydralazine or oxprenolol, nifedipine, atenolol, verapamil, nitroprusside, thiazide, spironolactone etc. It can also be overcome by weight reduction, regular physical exercise, limited alcohol consumption, stopping smoking, low intake of total and saturated fats, low intake of dietary salts and overall increase of fruits and vegetable intake (Poulter, et al., 2001; Williams, et al., 2004).Therefore, the right approach, including lifestyle changes, can achieve benefits to health and quality of life. Also, the disadvantages of antihypertensive drugs which include asthma, headaches, tiredness, and high costs could drastically reduce.

However, non-pharmacological strategies especially the dietary and exercising are difficult to maintain that patients barely respond to them despite its advantages. These facts stimulated the pursuit for another strategy to control BP. Past research has reported that slow and deep breathing significantly reduced BP in general(Anderson, McNeely and Windham, 2014; Bhavanani, Madanmohan and Sanjay, 2012; Matthew, 2015; Rickard, Reich, and Dunn, 2014; Sharma,. et al., 2013).

Moreover, physiologically BP has been found to decrease during inhalation and increase during exhalation (Matthew, 2015).Changes in different breathing pattern could be very vital to use the tactic to effectively reduce BP. There is little or no evidence on effect of different breathing patterns on automated SBP exists. This research is aimed to quantitatively investigate the effect of different breathing pattern on automated SBP when compared with automated baseline SBP measurement.

Method

SUBJECTS

Based on inclusion and exclusion criteria forty healthy subjects, 25 males and 15 females, aged 18 to 60, were engaged. The inclusion criteria were normal healthy subjects of age range of 18 to 60 years old. The exclusion criteria were participants with known hypertension and under antihypertensive medical treatment, or any cardiovascular disease. All subjects gave their written informed consent to participate in the study. Subject demographic information, including age, weight, and height and arm circumference are summarized in Table 1.

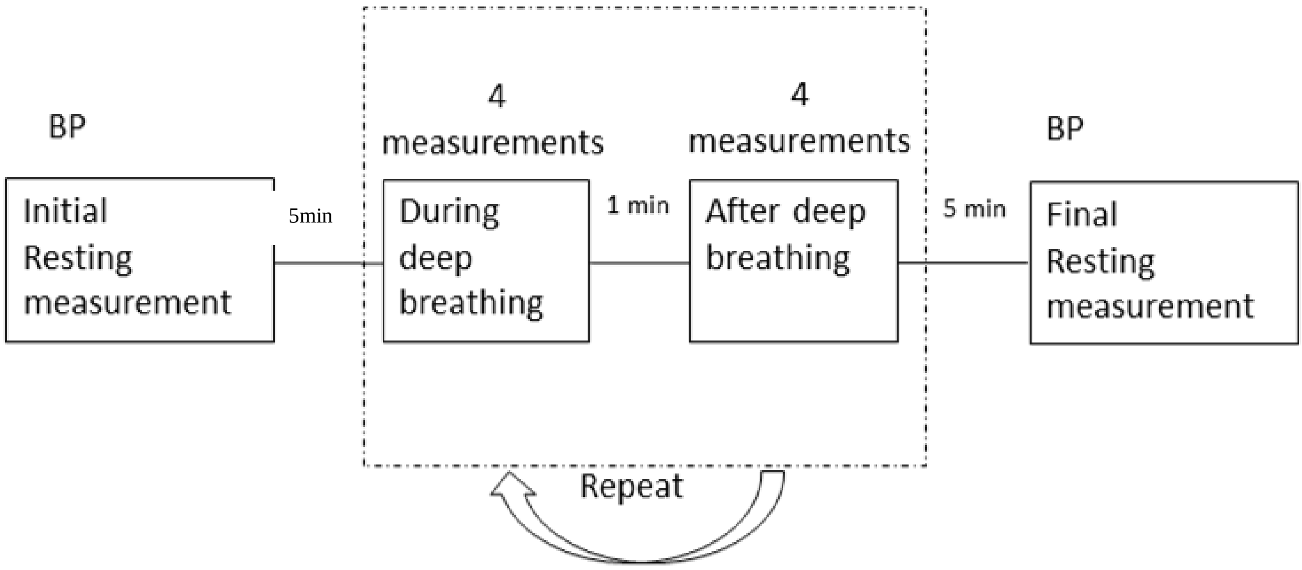
Data	Minimum	Maximum	Mean
Age	18	60	38
Height (cm)	150	180	160
Weight (kg)	50	106	72
Arm circumference (cm)	24	40	29

Table 1: Demographic data for the subjects studied

MEASUREMENT PROTOCOL AND PROCEDURE

The study was conducted in a quiet and cool measurement room to avoid distraction of subjects and at the same time make subjects comfortable. Subjects were requested to rest in a seated position for at least 5 min before BP measurement is taken. Systolic Blood Pressure (SBP) were measured from the left arm using a suitable cuff matched to individual arm circumference using a clinically validated automated BP device and following BP measurement procedure as indicated in ESH/ESC Guidelines (BHS,2013;O'Brien, et al., 2003).

Figure 1 display the two repeated measurement sessions for each subject. There were two baseline BP measurements under resting condition at the beginning and end of the two sessions. The eight BP measurements involve: four measurements during breathing using different patterns (Pattern 1 to Pattern 4) (**Pattern 1**: slow deep breathing with (4.5s of inhalation and 4.5s of exhalation); **Pattern 2**: long inspiration followed by short expiration with (6s of inhalation and 2s of exhalation); **Pattern 3**: short inspiration followed by long expiration with (2s of inhalation and 6s of exhalation); **Pattern 4**: fast deep breathing with (1.5s of inhalation and 1.5s of exhalation), and another four measurements of the same measurement after a one-minute rest interval. Figure 2(a, b, c and d) displays, the four different breathing patterns. A mobile phone application (Paced Breathing, Android App on Google Play) was used as a breathing guide and to adjust the time of the inhalation and exhalation and display the visual pattern on the screen. The order of the sequence of the four breathing pattern was randomised between subjects. Subjects practiced these four breathing patterns before the proper experiment to enable familiarity with them.



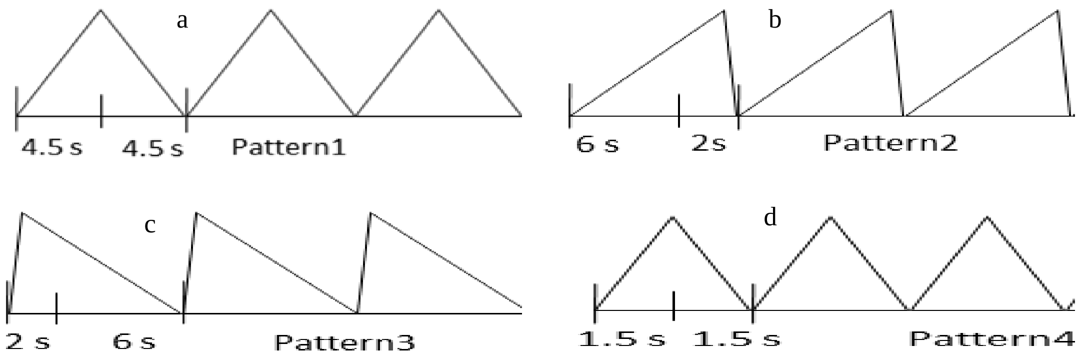


Figure 2(a, b, c and d): Illustrations of four different respiratory patterns

DATA AND STATISTICAL ANALYSIS

All recorded data were stored in Excel Spreadsheet. It was then transferred and analysed in statistical software SPSS 20.0. The means automated SBP were calculated, separately for baseline, during different respiratory patterns and after deep breathings. Analysis of variance was performed on SPSS 20.0 to investigate SBP measurement repeatability. The effect of different breathing patterns on automated SBP, and its difference during and after deep breathing was noted. A p-value below 0.05 was considered statistically significant.

RESULTS

AUTOMATED SBP MEASUREMENT REPEATABILITY

For SBP ($p = 0.4$) ANOVA analysis showed that automated baseline SBP measurements before and after the four different breathing patterns measurement sessions were repeatable. This prompted the use of their mean value 'Baseline' for further analysis. Automated SBP measurements during and after deep breathing were also repeatable between repeat sessions with $p = 0.498$ and their mean values were used as a reference value for each subject.

AUTOMATED SBP CHANGES DURING AND AFTER DEEP BREATHING IN COMPARISON WITH BASELINE

Figure 3 shows automated SBP measured during and after deep breathing.
Figure 4shows that automated SBP measured during deep breathing were significantly decreased in comparison with Baseline.

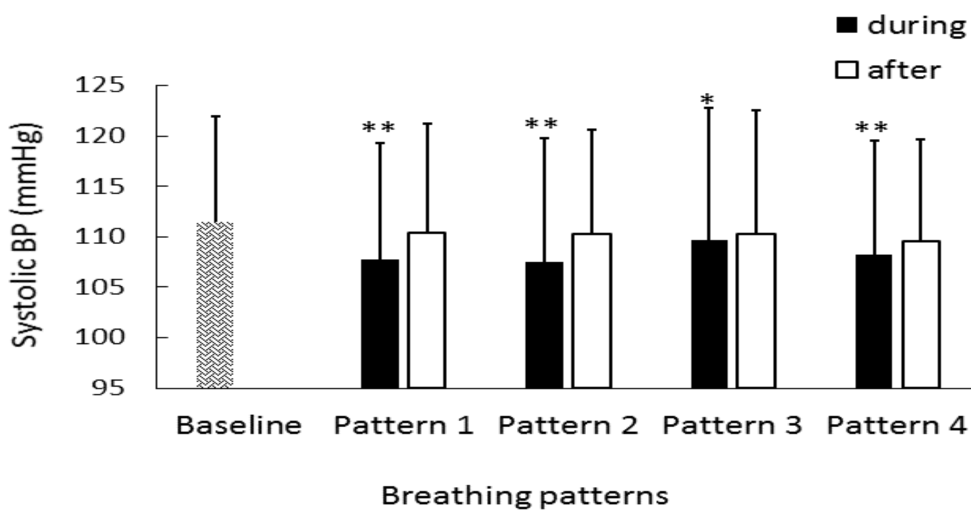
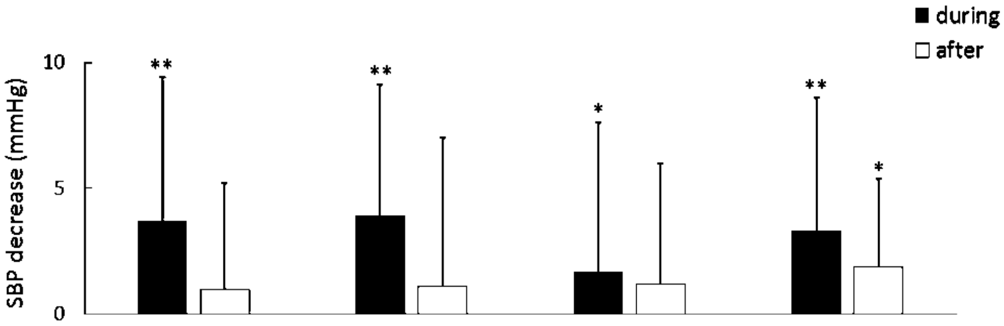


Figure 3: Means ± SDs of automated SBP during and after deep breathing with results from the four different breathing patterns in comparison with baseline automated SBP (** p< 0.001; * p< 0.05).



Pattern 1 Pattern 2 Pattern 3 Pattern 4
Breathing Patterns

Figure 4: Decrease of automated SBP during and after deep breathings in comparison with baseline (** p< 0.001; *p< 0.05).

Table 2 specifically shows the decreased automated SBP in Patterns 1, 2 and 4 by 3.7 ± 5.7 mmHg, 3.9 ± 5.2 mmHg and 3.3 ± 5.3 mmHg respectively (all p < 0.001), and SBP in Pattern 3 decreased by 1.7 ± 5.9 mmHg (p < 0.05). Automated SBP after deep breathing did not change significantly in comparison with Baseline in Patterns 1, 2, 3 (decreased by 1.0 ± 4.2 mmHg, 1.1 ± 3.46 mmHg, 1.2 ± 4.83 mmHg, with p > 0.05)

		During breathing	BP decrease	After breathing	BP decrease
	Baseline	111.5 ± 10.5			
SBP (mmHg)	Pattern 1	107.8 ± 11.5	3.7 ± 5.7 **	110.4 ± 10.7	1.0 ± 4.2
	Pattern 2	107.6 ± 12.2	3.9 ± 5.2 **	110.3 ± 10.3	1.1 ± 3.5
	Pattern 3	109.7 ± 13.0	1.7 ± 5.9*	110.3 ± 12.2	1.2 ± 4.8
	Pattern 4	108.2 ± 11.3	3.3 ± 5.3 **	109.5 ± 10.2	1.9 ± 3.5 *

Table 2:Means±SDs of automated SBP measured during and after deep breathing, and their differences in comparison with baseline BP. (** p< 0.001; * p< 0.05)

DISCUSSION AND CONCLUSION

In this study, effect of different breathing patterns on automated SBP was quantitatively demonstrated. This was the first study to systematically associate the different instant effect on automated SBP from four different breathing patterns with respect to different inhalation and exhalation duration.

Results of current study show the followings:

Pattern 1 (slow and deep breathing with 4.5 seconds inhalation and 4.5 second exhalation) achieved a significant decrease (p < 0.001) in automated SBP by 3.7 ± 5.7 mmHg, Participants were comfortable to follow pattern 1,agreeing with the findings of previous studies, that the slow and deep breathing could reduce BP(2, 4, 7, 13, 15, 16, 17, 18, 19, 20, 26).Slow deep breathing could lower BP via increased baroreflex sensitivity which regulated BP by controlling heart rate and diameter of blood vessels 31 and decreased sympathetic activity and chemoreflex activation. Bhavanani, et al. (2012) showed the use of pranayama slow and deep breathing to reduce BP in hypertensive patients within 5 minutes of practice with equal duration for inhalation and exhalation at the rate of 6 breaths/minute.

Pattern 2 with 6 seconds inhalation and 2 seconds exhalation shows significant decrease in automated SBP with 3.9 ± 5.2 mmHg ($p < 0.001$).This is due to physiological fact that the diaphragm contracts down and increases the volume of thoracic cavity as air is inhaled,24. However, the negative intra thoracic pressure increased and acts as a vacuum that pushes blood into the right side of the heart and venous system. The stroke volume in left ventricle is decreased at the same time and BP is reduced 24.The exhalation may increase after load on the heart which could increase BP 20.Itis therefore believed that if the period of inhalation is extended, that BP will decrease significantly. Martin Eisen (2009) observed that not all participants felt comfortable to perform pattern 2 during its experiment.Pattern2if practised for 3 to 4 weeks, subjects could manage to perform better (Gavish, 2010; Grossman, et al., 2001; Sharma, et al., 2013).

Pattern 3with 2 seconds inhalation and 6 seconds exhalation only achieved significant BP decrease in automated SBP with 1.7 ± 5.90 mmHg($p< 0.05$). This could be due to the physiology of exhalation that relates to a relaxation of diaphragm and an increase of intra thoracic pressure which refills the left ventricle with blood and results in increase of BP (Linsenbardt, Thomas, and Madsen, 1992; Matthew, 2015).

Pattern 4 shows significant decrease in automated SBP with 3.3 ± 5.3 mmHg ($p < 0.001$). Numerous participants grumbled of faintness with pattern 4. Meuret, et al., (2001) noted that the breathing could be kept effortless, otherwise the subjects may become hypocapnic or hypercapnic.

In addition, this study also showed that, the 1 min after deep breathing, automated SBP recovered back to normal with no significant difference in comparison with baseline automated SBP (all $p>0.05$) for pattern 1 to pattern 3.Automated SBP in pattern 4 shows a mean difference of 1.9±3.5 mmHg ($p< 0.05$), demonstrating the short-term effect of deep breathing on automated SBP.

This study was investigated on short-term effect of deep breathing on automated SBP; long-term effect should be investigated to confirm whether routinely performed sessions of deep breathing exercises could sustain reduction in SBP. Further study should also investigate effect of different breathing patterns on automated diastolic and mean arterial BP (DBP and MAP)

In conclusion, automated SBP decrease with different four breathing patterns has been quantitatively demonstrated and slow and deep breathing tends to be the most comfortable pattern for subjects to follow in practice.

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