THE IMPACT OF SLOW AND DEEP BREATHING ON CLINICAL BLOOD PRESSURES (BP) OF PREGNANT SUBJECTS USING AUTOMATED TECHNIQUE

*Nwobodo Nzeribe, H.N[1], Ani, O.I. [2].

1. Department of Computer Engineering, Enugu State University of Science and Technology, Enugu State, Nigeria.

2. Department of Mechanical and Production Engineering, Enugu State University of Science and Technology, Enugu State, Nigeria.

* Author for Correspondence: Nwobodo Nzeribe, H.N.; Email: nnennanwobodo@yahoo.com

ABSTRACT

This study offers quantifiable scientific data on impact of slow and deep breathing on clinical blood pressures (BP) measurement of pregnant subjects using automated technique. In this study twenty healthy pregnant subjects were involved. Automated Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were measured from each subject at different time points (before, during and after deep breathing). The automated BPs was then compared between the different time points. Experimental results showed that breathing decreased automated SBP and DBP significantly ($p < 0.001$) by 6.4 mmHg and 4.8 mmHg respectively during deep breathing. Similarly, automated SBP and DBP measured after deep breathing were also significantly ($p < 0.001$) decreased by 5.6 and 4.5 mmHg, respectively. 75% of the subjects had SBP reduction during deep breathing while 70% of subjects had SBP reduction after deep breathing. Similarly, 75% of the subjects had DBP reduction during deep breathing and the same percentage of subjects had DBP reduction after deep breathing.In conclusion, it has been demonstrated that clinical BPs of over half of the healthy pregnant subjects were significantly decreased with deep breathing using automatic BP techniques. Additionally, it can be suggested that deep breathing can be potentially used as a management tool to reduce BPs for some pregnant women. This could lead to development of breathing guided device for pregnant subjects with symptom of high BP.

Keywords: Automated technique, deep breathing, systolic, diastolic, blood pressure

1 INTRODUCTION

Blood pressure (BP) is one of the greatest commonly recorded clinical parameters in human physiological studies for over 250 years, for both clinical and research purposes (Shapiro, et al., 1996; Pickering, et al., 2005). Accurate, routine and reliable BP measurement is therefore essential for medical diagnosis and for monitoring response to therapy (Poulter, Thom and Kirby, 2001). Two non-invasive ways of measuring BP includes: the manual auscultatory and automatic oscillometric techniques. The manual auscultatory technique uses a sphygmomanometer and stethoscope, which is the gold standard for clinical BP measurement when it is performed by a well-trained operator while the automatic oscillometric technique analyses the pressure oscillations in a sphygmomanometer cuff during cuff deflation (Zheng, 2011). Automatic oscillometric technique was originally established by Marey in 1876 (Pickering, et al., 2005). It operates with the principle of amplitude oscillations of pressure in the cuff. During cuff inflation, each heart beat produces an oscillation in blood vessels, which corresponds to the amplitude of the cuff pressure oscillations. With this technique, BPs are determined indirectly via empirical derived algorithms and displayed electronically. Figure

1 shows the oscillometric waveform extracted from the deflating cuff pressure (bottom trace) and the oscillometric characteristic ratios for SBP, Mean Arterial Pressure (MAP) and DBP determination. MAP is determined at maximum point of the amplitude, SBP and DBP are estimated by the characteristic ratios of 0.5 and 0.7 respectively (Pickering, et al., 2005; Benmira, et al., 2016).

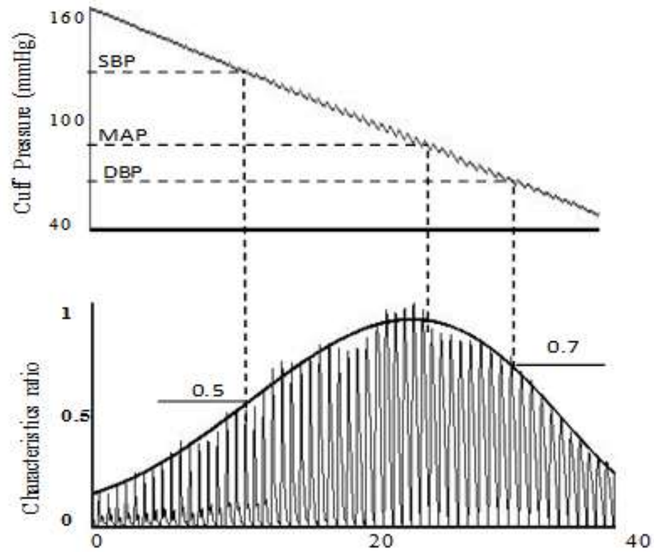

Figure 1: *Oscillometric waveform extracted from the deflating cuff pressure bottom trace) and the oscillometric characteristic ratios for SBP, Mean Arterial Pressure (MAP) and DBP determination. MAP is determined at maximum point of the amplitude; SBP and DBP are estimated by the characteristic ratios of 0.5 and 0.7 respectively*

Automated oscillometric devices are widely used because they are easy to operate and have the capability of reducing human error in comparison with the manual auscultatory technique especially when it is not performed by a trained observer.

Deep breathing has been widely accepted as one of the key factors imposing a physiological change in BP (Meles, et al., 2004; Grossman, et al., 2001; Elliot, et al., 2004; Mori, et al., 2005; Parati and Carretta, 2007; Zheng, et al., 2011; Mason, et al., 2013; Ravi, Narasimhaswamy and Anad, 2015; Drodz, et al., 2016; Zheng et al., 2012). It has been reported by Rosenthal, et al., (2000, 2001) and Viskoper, et al. (2003) that BPs could be reduced during deep breathing on non-pregnant subjects with a guided device. Past studies have also shown that BPs from hypertensive patients could be reduced with deep breathing for a short period of time (Schein, et al., 2001; Rosenthal, et al., 2001; Grossmann, et al., 2001; Viskoper, et al., 2003; Meles, et al., 2004; Elliot, et al., 2004, Augustovski, et al., 2004; Mori, et al., 2005; Elliot and Izzo, 2006; Parati and Carretta, 2007; Mourya, et al., 2009; Surbramanian, et al., 2011; Mahanti, et al., 2016; Drodz, et al., 2016; Wolff et al., 2016).

Furthermore, the influence of deep breathing on manual auscultatory BPs (systolic and diastolic blood pressures on non-pregnant subjects (SBP and DBP)) has been observed and quantified. (Rosenthal, et al., 2001; Meles, et al., 2004; Pickering, et al., 2005; Zheng, et al., 2011). Also, using measurements taken from different automatic BP devices, automated BP decreases with deep breathing have also been reported on non-pregnant subjects (Grossman, et al., 2001; Elliot, et al., 2004; Zheng, et al., 2011; Ravi, Narasimhaswamy and Anad, 2015). However, there is little or no quantitative clinical data available on the impact of slow and deep breathing on the clinical BP of pregnant subjects.

This study aimed to provide quantitative clinical data on effect of slow and deep breathing on clinical BP of normal pregnant subjects using automatic oscillometric techniques. The outcome of this will lead to suggesting if deep breathing could serve as a non- pharmacological approach to pregnancy induced hypertension (PIH) which will eventually lead to developing a breathing guided device for PIH patients.

2 METHODOLOGY

2.1. Subjects:

Twenty healthy pregnant women (aged 19 to 55 years old, and gestational age from three to nine months) were recruited to participate in this study. Any subjects with known history of cardiovascular diseases or other pregnancy-related diseases were excluded from the study. A total of twenty subjects were excluded because of the exclusion criteria. An ethical permission was received from the Park Lane Hospital, Enugu State, Nigeria. Table 1 summarizes the detailed subject demographic information including number of times of pregnancy, gestational age, arm circumference and age.

Table 1: Demographic data of pregnant subjects.

Subjects Information	Minimum	Maximum	Mean	Standard Deviation
Group of Subjects	Pregnant women			
No of subjects	20			
First pregnancy	10			
Pregnancy ≥ second time	10			
Gestational Age (weeks)	9	40	25	10
Age (Years)	19	37	28	5
Arm circumference (cm)	25	35	29	3

2.2. Blood Pressure Measurement Protocol and Procedure:

Figure 2 shows the block diagram of the measurement system. As shown, a clinically validated automatic BP device (Motech Truescan model BPU 500) was used to obtain automated BPs from pregnant women at different timings: before, during and after deep breathing.

Before each measurement, all residual air in the cuff was pushed out before wrapping it round the arm. The automated BP device was then placed properly on the table.

Figure 3 shows the BP measurement protocol. For each subject, 5 minutes rest was given before first baseline BP measurement. The subject was then asked to start deep breathing

at their own comfortable rate. After the fifth cycle of inhalation and exhalation, while the subject continued breathing, the second BP measurement was obtained. After this, 1 minute rest was given before the third measurement. A repeat session was performed for the whole procedure, giving a total of 6 measurements for each subject. A total of 120 BP measurements were obtained for all the 20 subjects. All the BP data collected from each subject were recorded on the designed data collection form. Other information included are: date and time of measurement, name, address, age, gestational age, arm circumference and other pregnancy information.

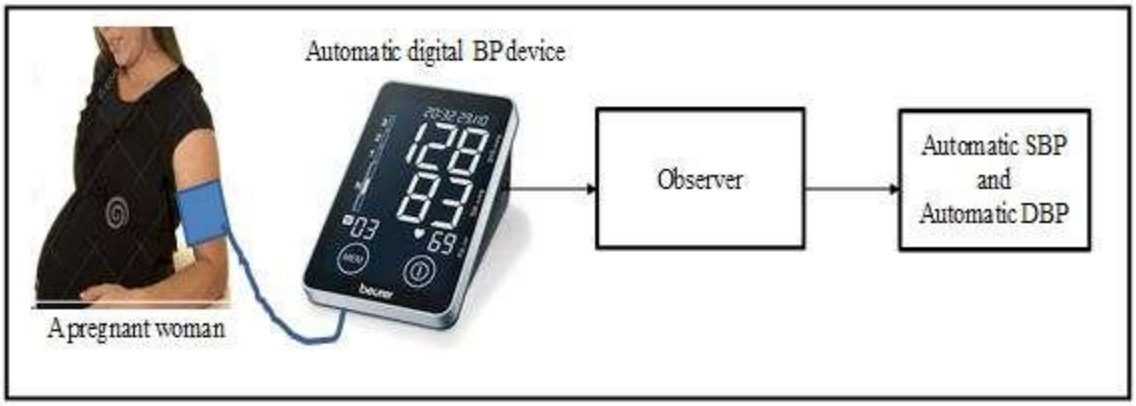

Figure 2: *Block diagram of BP measurement system.*

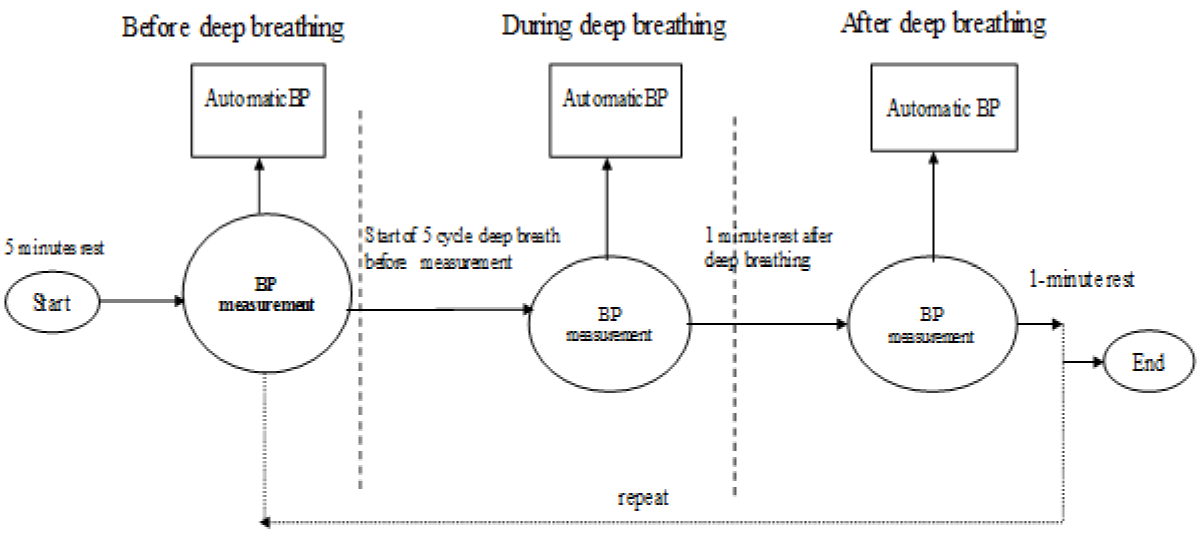

Figure 3: *Measurement protocol of the study*

2.3 Data and Statistical Analysis:

The data analysis for this study was performed using Excel and SPSS version 6.0. All the automated BP values in data collection forms were transferred into excel, where the means and standard deviation (SD) of automated BPs were calculated across all the subjects separately for the three conditions (before, during and after deep breathing). Next, Bland-Altman plots were produced to demonstrate measurement repeatability. SPSS 6.0 Statistics 17 software package (SPSS Inc., USA) was used to investigate measurement repeatability and the effect of deep breathing on automated BPs of pregnant women using ANOVA. Post-hoc multiple comparisons was then used to study within-subject BP decrease during and after deep breathing in comparison with resting condition (before deep breathing). The BP changes 'during and after deep breathing' in comparison with 'before deep breathing' were presented in mean difference ± SEM (Standard Error Mean) of difference. A p-value below 0.05 was considered statistically significant.

3 RESULTS

3.1 Measurement Repeatability of Automated BP:

Table 2 represents the mean and SD of the difference between the first and second repeat of BP measurement. For SBP, their differences were (-1.0 ± 12.8, -1.4 ± 9.5 and -1.3 ± 7.4) mmHg, respectively for the three different measurement points. The corresponding DBP differences were (-1.2 ± 10.9, 0.8 ± 6.7 and -1.1 ± 5.4) mmHg, respectively. There was no significant difference between the repeats (all p > 0.05). MAP (Mean Arterial Pressure) was not considered in data analysis because the device only provided SBP and DBP values. Figure 4 shows the level of agreement between first and second repeat by Bland-Altman plots.

Table 2: Mean and standard deviation (SD) of blood pressure (BP) measurement repeatability.

Mean and standard deviation (Mean ± SD) of automatic BP differences between repeatability (mmHg)			
(1st measurement – repeat)	**Before deep breathing**	**During deep breathing**	**After deep breathing**
SBP	-1.0 ± 12.8	-1.4 ± 9.5	-1.3 ± 7.4
DBP	-1.2 ± 10.9	0.8 ± 6.7	-1.1 ± 5.4

3.1 Comparison of Automatic BP Measured Before, During and After Deep:

Breathing:

Table 3 shows the mean ± SD of automated SBP and DBP across all subjects with the measurement taken before, during and after deep breathing. It shows that SBP decreased significantly by 6.4 ± 11.3 mmHg (103.2 ± 15.7 vs 109.6 ± 15.4 mmHg) during deep breathing and by 5.6 ± 9.6 mmHg (104.0 ± 14.2 vs 109.6 ± 15.4 mmHg) after deep breathing when compared with before deep breathing respectively. Similarly, DBP reduced significantly by 4.9 ± 6.8 mmHg (60.6 ± 9.1 vs 65.4 ± 10.9 mmHg) during deep breathing and 4.5 ± 8.4 mmHg (60.9 ± 9.8 vs 65.4 ± 10.9 mmHg) after deep breathing respectively, when compared with before deep breathing.

Figure 5 shows the comparison of automated SBP and DBP measured before, during and after deep breathing. Both SBP and DBP decreased significantly during deep breathing with p=0.001 when compared with before deep breathing. Automated SBP and DBP decreased significantly after deep breathing with p values of 0.003 and 0.001 respectively. There was no significant difference (p > 0.05) for both SBP and DBP between during and after deep breathing.

Table 3: Mean and standard deviation (SD) of automated SBP and DBP measured before, during and after deep breathing. Their decreases during and after deep breathing are presented in mean changes and standard error mean (SEM) of changes.

(Mean ± SD) of automatic BPs from pregnant women (mmHg)				BP decrease with deep breathing (Mean difference + SEM)	
BP parameter	**Before deep breathing**	**During deep breathing**	**After deep breathing**	**During**	**After**
SBP	109.6 ± 15.4	103.2 ± 15.7	104.0 ± 14.2	6.4 ± 2.5	5.6 ± 2.1
DBP	65.4 ± 10.9	60.6 ± 9.1	60.9 ± 9.8	4.9 ± 1.5	4.5 ±1.9

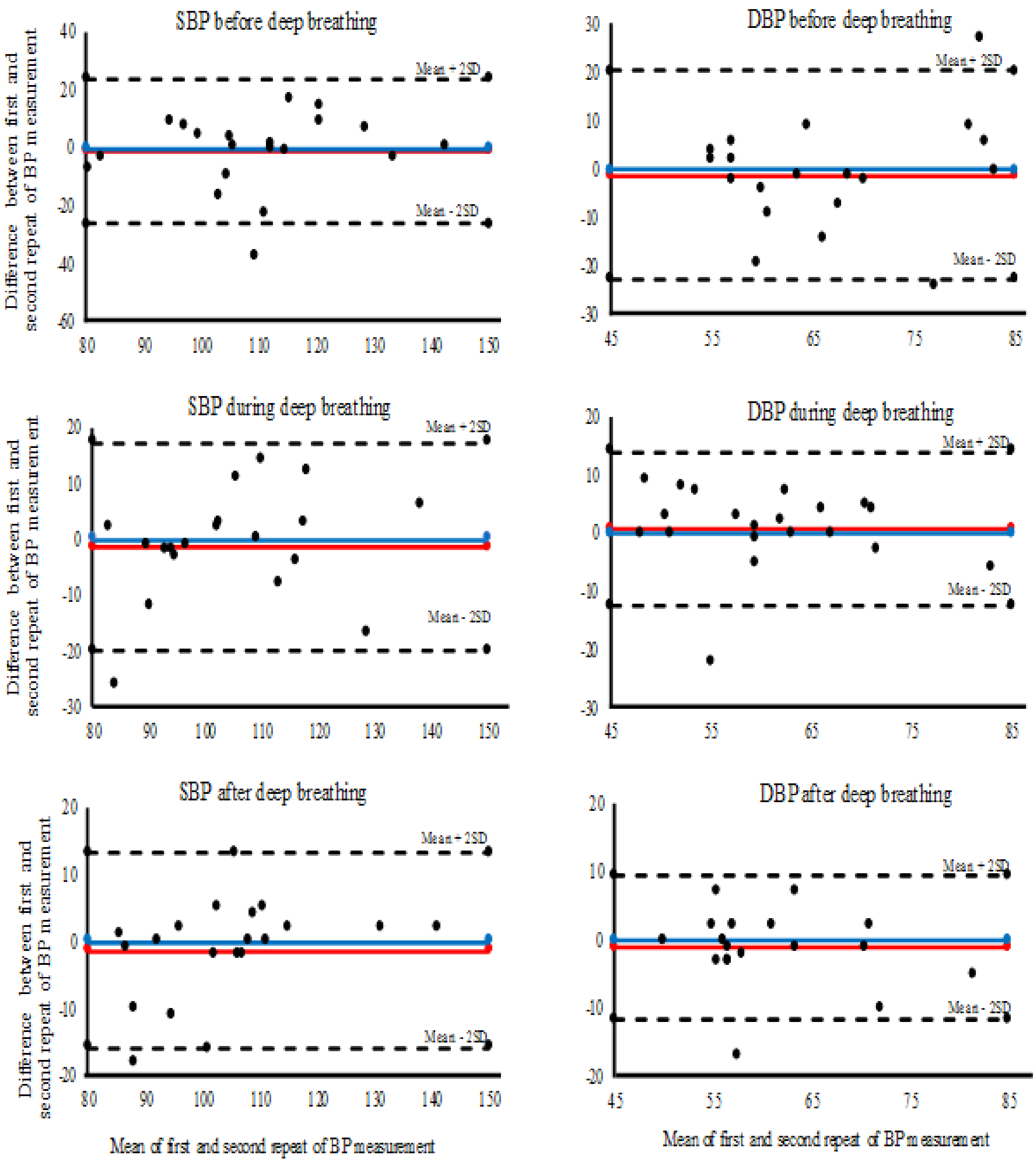

Figure 4: *Bland-Altman plots showing the measurement repeatability between the first and second repeat measurements. The limits of agreement (mean difference ± 2SD) are given.*

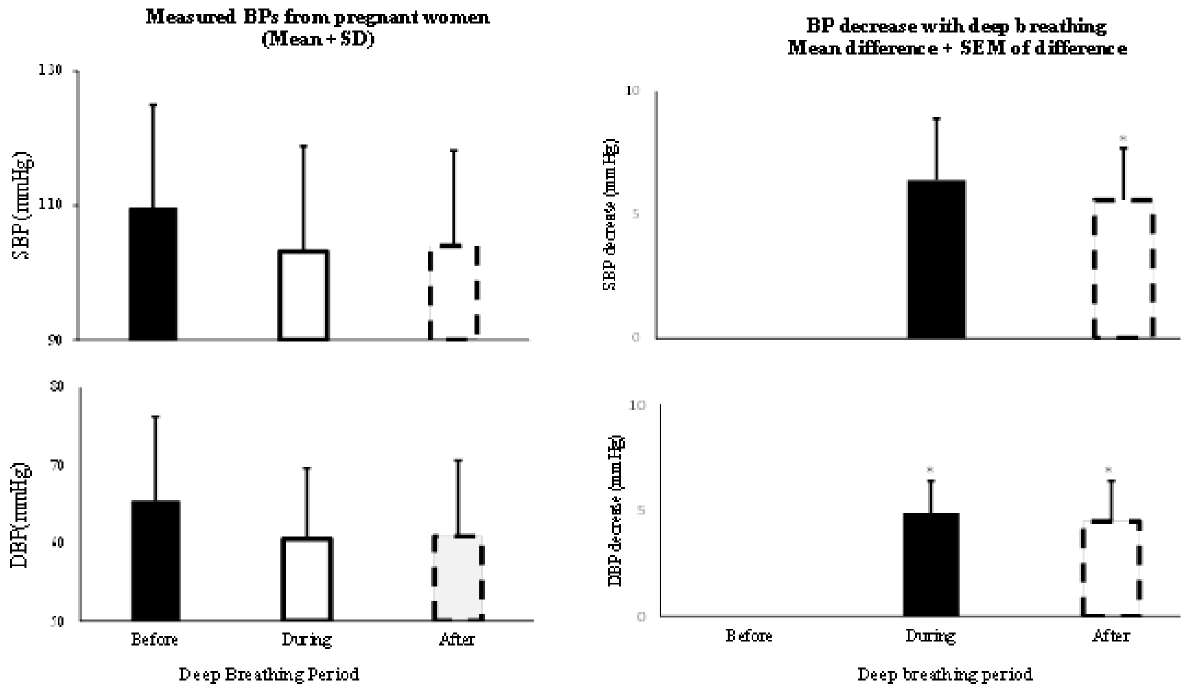

Figure 5: *Left: automated SBP and DBP measured before, during and after deep breathing (mean + SD); Right: BP decreases during and after deep breathing (mean difference + SEM of difference) (* indicates p<0.05 in comparison with the values before deep breathing).*

3.3 Individual BP Changes Before, During and After Deep Breathing

Figure 6 shows the individual SBP changes before, during and after deep breathing. Each line represents each subject and BP changes. It is observed that 75% of the subjects had SBP reduction during deep breathing and 70% of subjects after deep breathing. Similarly, Figure 7 shows the individual DBP changes before, during and after deep breathing. It is observed that 75% of the subjects had DBP reduction during deep breathing and the same percentage of subjects had DBP reduction after deep breathing.

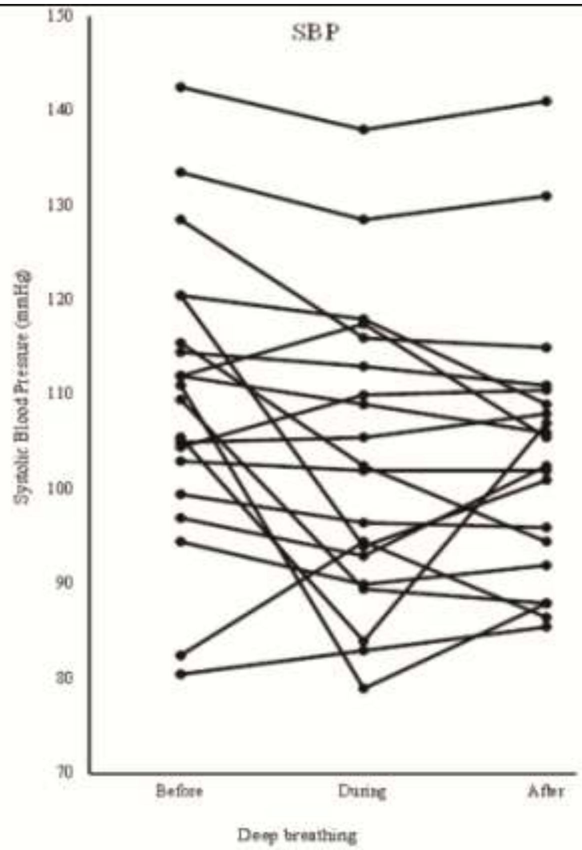

Figure 6: Individual automated systolic blood pressure (SBP) values measured before, during and after deep breathing in pregnant women.

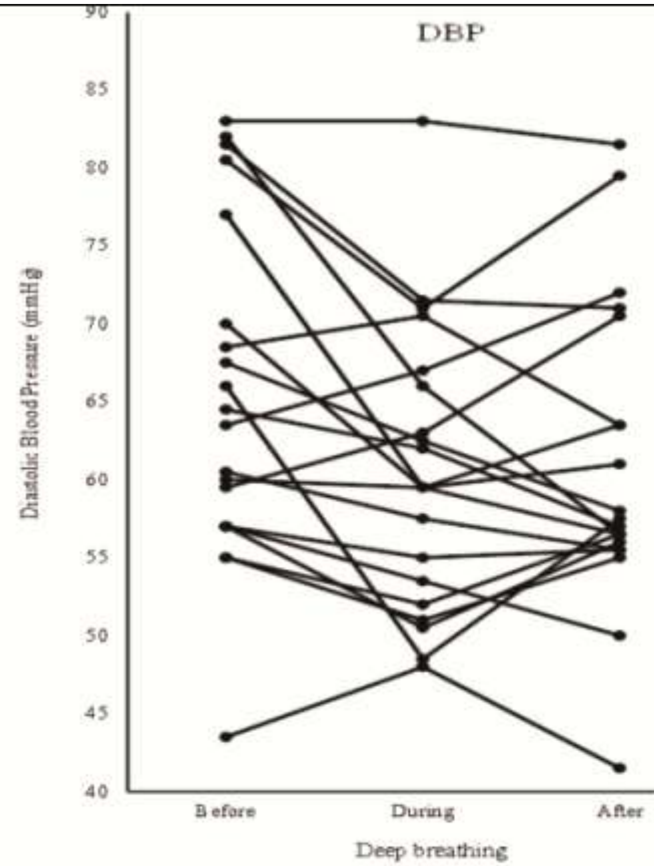

Figure 7: Individual automated diastolic blood pressure (DBP) measured before, during and after deep breathing in pregnant women.

4.0 DISCUSSION AND CONCLUSION

This study quantitatively demonstrated that automated BPs of pregnant subjects decreased significantly with deep breathing when compared to during and after resting condition. The automated SBP and DBP decrease with deep breathing also agreed with published studies with measurements taken from different automatic BP devices (Ravi, Narasimhaswamy and Anand, 2000; Grossman, et al., 2001; Viskoper, et al., 2003; Elliott, et al., 2004; Elliott and Izzo, 2006; Parati and Carretta, 2007).

It was also shown that BPs from non-pregnant patients with high BP was reduced with deep breathing for a short period of time (Schein, et al., 2001; Rosenthal, et al., 2001; Grossmann, et al., 2001; Viskoper, et al., 2003; Meles, et al., 2004; Elliot, et al., 2004, Augustovski, et al., 2004; Mori, et al., 2005; Elliot and Izzo, 2006; Parati and Carretta, 2007; Mourya, et al., 2009; Surbramanian, et al., 2011; Mahanti, et al., 2016; Drodz, et al., 2016; Wolff et al., 2016). However, there is no study investigating the practice of respiratory exercise for pregnant subjects. Results from this study showed that deep breathing had a positive reduction effect on SBP and DBP on normotensive pregnant women, providing the scientific evidence that deep breathing can be served as a potential substitute to pharmacological management of high BP during pregnancy.

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