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Effect of Slow Breathing on Blood Pressure, Heart Rate and Body Weight in Prehypertensive Subjects of Varying Body Mass Index

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Abstract: ***Purpose: Individuals with higher BMI have increased blood pressure and resting heart rate. Slow breathing done at 6 breaths/min increases the baroreflex sensitivity and reduces sympathetic activity suggesting a potentially beneficial effect in hypertension. Method: 45 subjects of different BMI were selected. The subjects performed slow breathing for 4 weeks. Systolic BP, diastolic BP, heart rate and body weight changes from baseline. Data was analysed by using Wilcoxon signed rank test and Kruskal wallis test. Results: BP reductions were seen in normal BMI (p<0.05) and overweight (p<0.05) subjects, whereas no reductions in BP were seen in obese prehypertensives (p>0.05). Heart rate was reduced in normal BMI group (p<0.05) and no significant reductions were seen in overweight (p>0.05) and obese (p>0.05) subjects. But, body weight was found to be significantly decreased in obese subjects (p<0.05), whereas no significant reductions in body weight occurred in normal BMI (p>0.05) and overweight (p>0.05) subjects. Conclusion: Slow breathing reduced the blood pressure and heart rate of normal BMI and overweight prehypertensive subjects. However, slow breathing is not effective in reducing the blood pressure and heart rate in obese prehypertensive subjects, but it may play a role in weight reduction of obese prehypertensives.***

Keywords: Slow breathing, prehypertension, blood pressure, heart rate, BMI

1. Introduction

Prehypertension is a precursor of clinical hypertension and is closely related with the increased incidence of cardiovascular diseases and cardiovascular risk factors such as obesity, diabetes mellitus and dyslipidemia.[1] Higher BMI has been found to alter the blood pressure significantly, as there is a substantial evidence that body weight and weight gain are the major determinants of the rise in blood pressure that commonly occur with ageing.[2] Weight gain since age 20 and the measures of total and regional adiposity are positively and significantly associated with levels of blood pressure in a dose dependent manner.[2]

The vagal withdrawal plays an important role in the alteration of sympathovagal imbalance with increase in BMI in prehypertensive subjects and the intensity of sympathovagal imbalance was found to be more prominent in prehypertensive subjects with higher BMI compared to prehypertensive subjects with normal BMI.[3] The basal heart rate was also found to be significantly increased in perhypertensive subjects with higher BMI as compared to the normal BMI subjects and prehypertensive subjects with normal BMI, indicating a significantly lower vagal tone in prehypertensive subjects with higher BMI.[3] A 10% increase in body weight is associated with a decline in parasympathetic tone, accompanied by a rise in mean heart rate, and conversely, heart rate declines with the weight reduction suggesting that the resting heart rate is positively correlated with BMI.[4] JNC-7 has suggested that the individuals with prehyertension should adopt a healthy lifestyle in order to lower blood pressure and prevent progression to hypertension with associated reductions in target organ damage and cardiovascular events.[1]

Various attempts have been made till date to lower the blood pressure in individuals with prehypertension using relaxation training, biofeedback, alternative medicine, breathing control meditation and by the use of a device that guides slow deep breathing. Studies have shown that reducing sympathetic activation and increasing baroreflex sensitivity in hypertension would help in reducing blood pressure, and it is interesting to note that slow breathing done at 6 cycles/min increases the baroreflex sensitivity in normal subjects and in patients with chronic heart failure.[5] However, there exist a lack of evidence could relate the effects of slow breathing in reducing blood pressure and heart rate with body weight. And, as the prehypertension is related to BMI there is a need to investigate the efficacy of slow breathing in prehypertensive subjects of different BMI. Also, the breathing exercises in yoga have been found to help in reducing the body weight by boosting the metabolism[6] and by activation of the parasympathetic nervous system[7], so the slow breathing can be thought to be helpful in reducing body weight. So, there is a need to know the effects of slow breathing on body weight. So, the main objectives of this study were to determine the effects of slow breathing on blood pressure, heart rate and body weight in prehypertensive subjects of different BMI and to compare its effects among different BMI.

2. Methods

2.1 Patient selection

This prospective, randomised experimental study was conducted in accordance with the principles of good clinical practice. The protocol was approved by Ethics Committee of the Lovely Professional University and the written consent was obtained from all patients.

The study consisted of 45 subjects (male and female both) 19-35 years of age with prehypertension i.e systolic blood pressure ranging from 120-139 mm Hg and diastolic blood pressure ranging from 80-89 mm Hg. Exclusion criteria were prehypertension because of secondary causes, drinking ethanol >60g/day, smokers, diabetes mellitus, use of any medication that would interfere with CNS activity. Eligible patients were randomly assigned in a 1:1:1 ratio into three groups based on BMI (group I containing subjects with BMI ranging from 18-24.9 Kg/m^2, group II containing subjects with BMI ranging from 25-29.9 Kg/m^2 and group III containing subjects with BMI >30.0 Kg/m^2) to undergo 4 weeks of slow breathing using lottery method.

2.2 Procedure

Before the commencement of the study blood pressure was measured in a sitting position, after the patient had rested for 5 mins. All the readings were taken with an appropriately sized cuff placed on the right upper arm parallel to the trunk. The phase I korotkoff sound to define the systolic blood pressure and the disappearance of sound (phase V) as the measurement of diastolic blood pressure. A single BP measurement was determined as follows:- two readings using a standard mercury sphygmomanometer. Heart rate was measured through radial pulse of the right arm using a stop watch for one minute. The BMI was checked for all the subjects using a standard weighing machine and stadiometer.

2.3 Protocol

Subjects were told to practice slow breathing at the rate of 6 breaths/min for 10 mins daily for 4 weeks. The treatment took place at home, during evening time, with the patient seated comfortably in a quiet room and avoiding any disturbances for example, use of telephone, television or talking to another person. The patient's compliance was checked by a personal diary they had been asked to sign each day, confirming that they had carried out the treatment. At the end of 4 week of treatment, the final measurements for blood pressure, heart rate and body weight were taken. The subjects were also questioned for adverse reactions, and comments reported during the study were noted. The rules for patient's withdrawal from the study were any change in the medical condition that would not allow the patient to continue with the treatment protocol. Secondly, non adherence to the protocol, mainly failure to visit for final measurements.

2.4 Statistical analysis

SPSS version 16.0 was used for the statistical anlaysis. For comparing the data within the group Wilcoxon Signed Rank test was used. For comparing the data between the groups Kruskal Wallis test was used.

3. Results

3.1 Effect of slow breathing on blood pressure:

In prehypertensive subjects, the slow breathing significantly reduced the systolic and diastolic blood pressure among subjects of normal BMI (from 127.33 mm Hg to 116.53 mmHg, P <0.05 and from 85.73 mm Hg to 76.26 mmHg, P<0.05) and overweight (from 127.6 mm Hg to 117.73 mm Hg, P <0.05 and from 86.66 mm Hg to 80 mm Hg, P<0.05) (figure I A). With the slow breathing obese subjects did not showed the improvements in systolic as well as diastolic blood pressure (from 128.66 mm Hg to 127.46 mm Hg, P>0.05 and from 86.26 mm Hg to 84.26 mm Hg, P>0.05) (figure I B) (table I). On comparing the data between the different BMI, significant changes were found (P<0.05) (table II).

3.2 Effect of slow breathing on heart rate:

Slow breathing significantly reduced the heart rate in normal BMI (from 79.2 beats/min to 75.66 beats/ min, P<0.05) (figure I C), whereas no significant results were found in overweight and obese subjects (from 81.53 beats/min to 78.6 beats/min, P>0.05 and from 81.53 beats/min to 78.6 beats/min, P>0.05) (table I). On comparing the data between the different BMI significant change was seen (P<0.05) (table II)

3.3 Effect of slow breathing on body weight:

Obese subjects showed a significant decrease in the body weight with slow breathing (from 87.66 kg to 85.86 kg, P<0.05), where as subjects of normal BMI and overweight subjects showed no significant changes in the body weight with slow breathing (from 58.06 kg to 57.26 kg, P>0.05 and from 73.73 kg to 73 kg, P>0.05) (figure I D) (table I). On comparing the data between the different BMI, no significant change was seen (P>0.05) (table II).

4. Discussion

4.1 Effect of slow breathing on blood pressure in prehypertensive subjects of different BMI:

A total of 45 prehypertensive subjects of varying BMI participated and completed the study. In this study it was found that slow breathing done at the rate of 6 cycles/min for atleast 10 mins daily for 4 weeks, had significantly decreased the blood pressure (systolic and diastolic) in prehypertensive subjects of normal BMI and overweight, whereas no significant effect was seen in obese subjects. Our findings are consistent with the results of previous studies. But our study is the first to demonstrate how the effectiveness of slow breathing is related to the BMI.

Table 1: Comparison of the variables within the groups

Variable	Baseline	After 4 weeks	P value
Normal BMI			
SBP (mm Hg)	127.33 ± 1.799	116.66 ± 5.462	0.000*
DBP (mm Hg)	85.73 ± 7.815	76.26 ± 10.471	0.000*
Heart rate (beats/min)	79.2 ± 6.259	75.66 ± 3.958	0.001*
Weight (Kgs)	58.06 ± 6.375	57.26 ± 7.245	0.071
Overweight			
SBP (mm Hg)	127.6 ± 4.222	117.73 ± 6.863	0.000*
DBP (mm Hg)	86.66 ± 7.622	80 ± 5.606	0.001*
Heart rate (beats/min)	81.53 ± 5.194	78.6 ± 5.068	0.207
Weight (Kgs)	73.73 ± 9.662	73 ± 10.413	0.180
Obese			
SBP (mm Hg)	128.66 ± 3.677	127.46 ± 5.753	0.749
DBP (mm Hg)	86.26 ± 6.84	84.26 ± 7.32	0.159
Heart rate (beats/min)	81.46 ± 5.462	82 ± 5.071	0.803
Weight (Kgs)	87.66 ± 8.226	85.86± 8.175	0.000*

(Note * indicates p<0.05)

Table 2: Comparison of the parameters between the groups

Parameters	*Normal BMI*		*Overweight*		*Obese*		*P*
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	
SBP (mm Hg)	127.33	116.53	127.6	117.73	128.66	127.46	0.000*
DBP (mm Hg)	85.73	76.26	86.66	80	86.26	84.26	0.003*
Heart Rate (beats/min)	79.2	75.66	81.53	78.6	81.46	82	0.003*
Weight (Kgs)	58.06	57.26	73.73	73	87.66	85.86	0.3

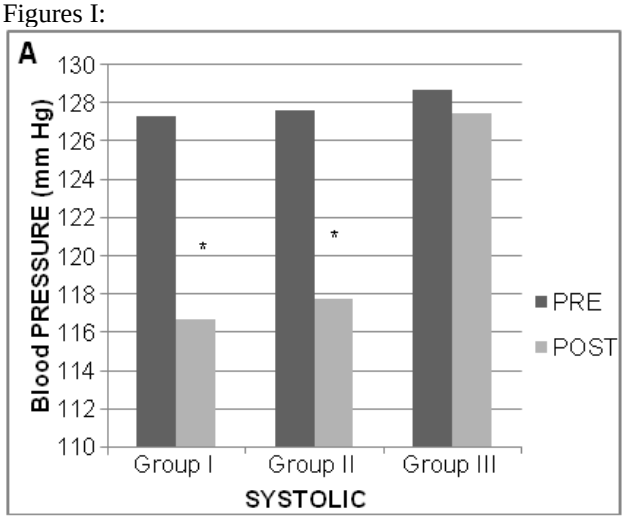
(Note * indicates p<0.05)

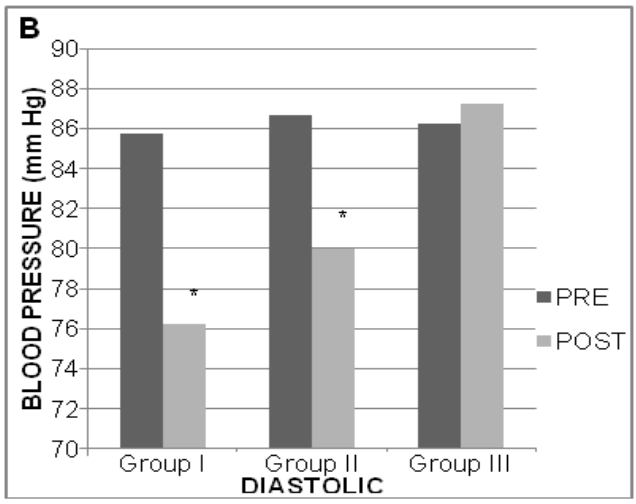
Table 3: Baseline characteristics of patients

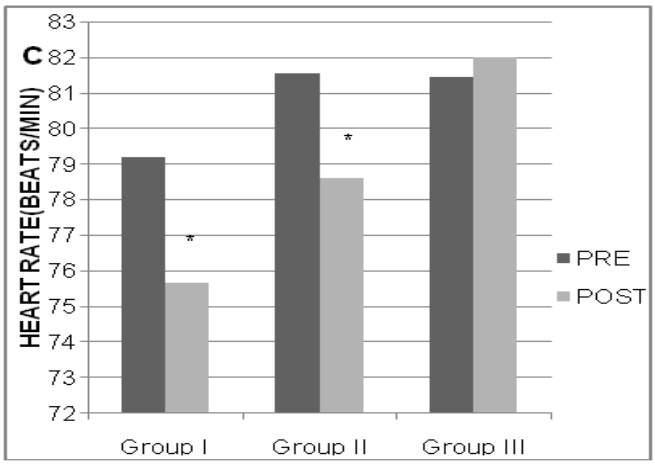
Parameters	Normal BMI	Overweight	Obese
Age (Years)	21.2 ± 1.375	22.06 ± 2.18	21.6 ± 3.66
Body weight (kgs)	58.06 ± 6.374	73.73 ± 9.66	87.66 ± 8.22
Height (m2)	5.34 ± 0.223	5.32 ± 0.467	5.39 ± 0.271
BMI (Kg/m2)	22.825 ± 1.50	27.39 ± 1.336	32.91 ± 2.527
SBP(mm Hg)	127.33 ± 1.799	127.6 ± 4.222	128.66 ± 3.677
DBP(mm Hg)	85.73 ± 7.815	86.66 ± 7.622	86.26 ± 6.84
HR(beats/min)	79.2 ± 6.259	81.53 ± 5.194	81.46 ± 5.462

5. Figures

Figures I:







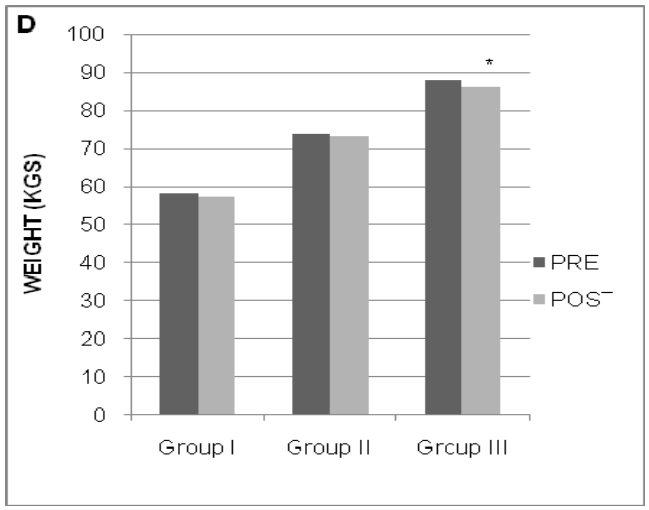


Figure 1: Effect of slow breathing on A. Systolic blood pressure, B. Diastolic blood pressure, C. Heart rate D. Body weight. (Note * indicates p<0.05)

There are various mechanisms that support the present findings. Slow breathing has been found to be associated with the enhanced Baroreflex sensitivity, both in healthy and in presence of CHF as concluded by Bernardi et al, which seems to occur through a relative increase in vagal activity and a reduction in sympathetic activity, causing reductions in both systolic and diastolic blood pressure.[5]

Secondly, it leads to an increase in tidal volume, which compensates for the reduced breathing rate in order to

maintain minute ventilation and could be responsible for these autonomic changes through a reduction in sympathetic activity or via the Hering- Breuer reflex as concluded by Bernardi et al.[5]

Thirdly, the lung inflation which increases with decreasing breathing rate, stimulates slowly adapting pulmonary stretch receptors and this neural activity serves as an input to the medulla and is integrated with the information about BP level generated by arterial baroreceptors [8] and as an acute response to BP elevation and / or lung inflation, vasodilation occurs in a number of vascular territories, such as the limbs, skin, muscles, kidney and splanchnic vascular bed.[9] It seems that slow breathing induces a generalised decrease in the excitatory pathways regulating respiratory and cardiovascular system.[9]
Lastly it has also been considered that respiratory and cardiovascular systems share similar control mechanisms, thus alterations in one system will modify the functioning of the other.[9] For example, in essential hypertension, the sympathetic hyperactivity has been found to be associated with a generalised enhancement of the excitatory pathways, leading not only to sympathetic vasoconstriction, but also chemoreflex activation.[9] Therefore, one can expect that a modification in the respiratory control would affect the control of the cardiovascular system and as the breathing is under voluntary control, it is theoretically possible to induce such changes by voluntary modifications of breathing.[9]

But in our study the slow breathing was not found to be effective in reducing the blood pressure in obese prehypertensive subjects. Obesity has been found to cause autonomic disturbances. BMI has been found to be strongly correlated with all the cardiovascular parameters including SBP and DBP in all prehypertensive subjects and it has been suggested that the alterations in plasma levels of leptin, neuropeptide-Y and α-MSH (melanocyte- stimulating hormone) might be involved in activation of sympathetic activity that leads to hypertension in obese patients.[3] Also the visceral adipose tissue has been found to secrete a variety of bioactive substances, termed adipocytokines, such as, tumour necrosis factor-α (TNF-α), interleukin-6 (IL-6), angiotensinogen, and non- esterified fatty acids (NEFA), which play a role in development of hypertension and metabolic syndrome.[4]

Another report states that cardiac dysfunctions associated with insulin resistance, oxidative stress and inflammation are dependent on the quantity of fat mass in obese, but not in overweight children.[3] So the SVI caused by increased adiposity is among the major predictors of increase in blood pressure in prehypertensives and therefore this increased adiposity could be related to the less alterations in blood pressure among obese prehypertensives.[3]

5.1 Effect of slow breathing on heart rate on prehypertensive subjects of different BMI.

The heart rate was found to be decreased significantly in subjects with normal BMI only where as no changes were seen in overweight and obese subjects. The possible mechanism for the decrease of heart rate in normal BMI subjects could be, the slow breathing leads to the relative increase in vagal activity and reduction in sympathetic activity as concluded by Joseph et al. [9]

The possible mechanisms for the no significant changes of heart rate among the overweight and obese could be, the autonomic dysfunction associated with the obesity that leads to higher RHR (resting heart rate) and a greater change in RHR on changing the posture as compared to non- obese individuals as concluded by Talay yar.[4]

In another study it has been said that although cardiac automaticity is intrinsic to various pacemaker tissues, heart rate and rhythm are largely under the control of autonomic nervous system and it exerts its action through sympathetic and parasympathetic limbs. The sympathetic influence is mediated by release of epinephrine and nor epinephrine on sinus node and increases the heart rate where as parasympathetic influence is mediated via release of acetylcholine by vagus nerve and decrease in heart rate.[10] An increase in sympathetic stimulation in obesity leads to the increase in heart rate and contractility, even under the resting conditions as concluded by Damodaran and Kabali.[10]

Also it has been found that the 10% increase in body weight is associated with a decline in parasympathetic tone, accompanied by a rise in mean heart rate, and conversely, heart rate declines during weight reduction.[4] Reductions in vagal activity with increment in weight may be one mechanism for the arrhythmias and other cardiac abnormalities that accompany obesity.[4] Since autonomic disturbances appear to be reversible with weight reduction, improvement obtained from weight loss should be beneficial for the health of individuals with obesity along with slow breathing.[4]

5.2 Effect of slow breathing on body weight in prehypertensive subjects:

The body weight was found to be significantly reduced with the slow breathing in obese subjects. It is said that oxygen is highly inflammable substance that speeds up the chemical reactions in the body, and also it thins the blood a little which helps to lower the blood pressure and speed up the flow of blood. This increases the metabolism and burns more calories. The more the oxygen present in the blood, faster will be the metabolism, also the more energy, and more calories will be burnt.[6] It has also been found that deep breathing in yoga triggers the release of hormones from thyroid gland that stimulate metabolism and thereby indirectly leads to weight loss.[11]

Another important aspect of deep breathing exercise and weight loss is related to the relaxation response. When body is stressed the brain tells the adrenal gland to secrete cortisol, it also release excess insulin which increases the storage of fat and increases the cravings for more sweet foods. Simply by doing deep breathing, one can relax his/her body and can get rid of stress and eliminate this vicious cortisol-insulin stress cycle that stimulates excess fat retention.[7]

Although, slow breathing decreased the body weight in normal BMI and overweight group, but significant reductions were not seen. As, already the subjects belonging to these groups are known to have less metabolic problem as compared to the obese so less changes were seen in these groups as compared to obese, who are known to have poor digestion and their bodies hold on excess toxins and waste products as well as water and deep breathing helps in improving the digestion and aids the body in removing excess waste products from the digestive system thereby causing a reduction in body weight.[12]

In conclusion this study shows that slow breathing may play a significant role in reducing the blood pressure and heart rate of normal BMI and overweight prehypertensive subjects. However it has also been found that slow breathing is not effective in reducing the blood pressure and heart rate in obese prehypertensive subjects, but it may play a role in weight reduction of obese prehypertensives. The limitations for this study were, firstly it has small sample size. And secondly, in this study the dietary habits of the subjects were not taken into consideration.

6. Future Scope

Further studies can be done by practicing slow breathing for 6 months or 1 year and by evaluating the effects obtained. Large sample size can be used for further research. The effect of slow breathing along with weight reduction therapy in obese subjects could be studied. The effect of slow breathing on the lipid profile can be studied in future.

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