Original Research Article

Additive Effects of Diaphragmatic Breathing on Galvanic Skin Response, Blood Pressure, Pulmonary Function Test in Persons with Essential Hypertension

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ABSTRACT

Introduction: Hypertension known as a raised arterial pressure. It is a major risk factor for cardiovascular morbidity and mortality. Stress is one of the factors that is responsible for hypertension which is measured by galvanic skin response (GSR). Findings from the previous studies were showed that the breathing exercise can help in the reduction of the blood pressure by acting on autonomic nervous system. Several studies have shown the effects of aerobic exercise in reduction of the blood pressure but there was scarcity of the studies done on additive effects of diaphragmatic breathing on essential hypertension.

Materials and Method: After taking informed written consent subjects were randomly divided into two groups by simple random sampling method. Group A received Aerobic exercise and Group-B received Diaphragmatic breathing + Aerobic exercise. The duration of the treatment was of the 4 weeks. Pre and post intervention BP, GSR, FVC, FEV_1 and DASS 21 were measured.

Results: Paired t test and Wilcoxon signed rank test were used for within group analysis which shows the significant improvement was found in both groups in all outcome measure. There was significant difference was found in between groups in FVC and FEV_1 (p < 0.05). However there was no statistical significant difference was found in between groups in SBP, DBP, GSR and DASS-21(p > 0.05).

Conclusion: Diaphragmatic breathing along with the aerobic exercise has significant effects on FVC and FEV_1 however there were no additional significant effects found on BP, GSR and DASS-21.

Key words: Hypertension, Diaphragmatic breathing, Aerobic exercise, Blood pressure, Galvanic skin response, pulmonary function test

INTRODUCTION

Hypertension (HTN), also known as high blood pressure (BP), affects millions of people. High blood pressure is defined as BP ≥140/90 millimeters of mercury (mmHg).[1,2] Prehypertension or stage I hypertension is categorized as consistently elevated systolic blood pressure (SBP) and diastolic blood pressure (DBP) ranging from

120 to 139 mmHg and from 80 to 89 mmHg,respectively.[1,2] Hypertension is consistently related to the development of ischemic heart disease, heart failure, stroke, and chronic kidney disease; an estimated 57% and 24% of stroke and coronary artery disease-related deaths, respectively are due to hypertension.[3] Most important risk factors that influence the essential hypertension are stress and obesity. Psychological stress is also a common factor contribute to essential hypertension. Chronic stress has become a serious problem affecting different life situation and carries a wide range of health related disorders such as cardiovascular disease, cerebrovascular disease, and Diabetes and Immunological disorders.[4] there is a high prevalence of HTN in India among young adults (20-44 years) with overall prevalence of hypertension was 30.7% in india.[3, 4]

The Galvanic Skin Response (GSR) is outlined as a change in the electrical properties of the skin. The signal can be used to measure the response of autonomic nervous system as a parameter of the sweat gland function. The response seems as an increase in the electrical conductance of the skin (a decrease in resistance) across the palms of the hands or soles of the feet.[5]

Diaphragmatic breathing defined as an efficient integrative body–mind training for dealing with stress and psychosomatic conditions. It involves contraction of the diaphragm, expansion of the belly, and deepening of inhalation and exhalation, which consequently decreases the respiration frequency and maximizes the amount of blood gases.[6]

Breathing exercise is one of the measures for the reduction of the stress. Stress is factor that can lead to the development of the hypertension. All this can lead to the increasing the risk factors for the cardiovascular impairments. There are evidences that shows the breathing exercise may help in reduction of the blood pressure by acting on the autonomic nervous system. Galvanic skin response is an outcome measure that shows the stress of the body and diaphragmatic breathing is helps to reduction of the stress by acting on the autonomic nervous system and may also help to reduce blood pressure.[6]

Aerobic exercise is one amongst nonpharmacological treatment methods and is recommended by European and American hypertension guidelines to reduce blood pressure. It is reported that moderate intensity aerobic exercise may reduce both systolic blood pressure (SBP) and diastolic blood pressure (DBP) in both male and female patients with essential hypertension in pre- or stage 1.[7]

Previous studies are found that shows effectiveness of breathing exercise on reduction of blood pressure and it acts on the body by directly acting on autonomic activity that which will also help to change the cardiovascular dynamics that helps to enhances the function on cardiovascular system.

MATERIAL AND METHODS

- **Study design:** Interventional study
- **Sampling method:** Simple random sampling
- **Sample size:** 24
  pooled standard deviation of 5.45 units determine that the means of the test and the reference groups are 123 and 116.56 units, respectively, and the standard deviation is 5.45 units, you would have 80% power to declare that the two groups have significantly different means, i.e. a two sided p-value of less than 0.05.(Group A- 12,Group B- 12)
- **Total study duration:** 6 months
- **Study settings:** In Ahmedabad

Inclusion criteria
➢ Subjects willingness to participate.
➢ Males and females between ages of 30 – 60 years.
➢ Subjects are having essential hypertension in prehypertensive stage and stage 1, according to JNC 8 Classification.[7]
➢ Subjects who are taking treatment.

Exclusion criteria
➤ Significant co-morbidity like angina, uncontrolled diabetes mellitus, chronic renal failure, stroke, obesity and musculoskeletal conditions in lower limb.

Withdrawal criteria
➤ If subject wishes to discontinue treatment.

Materials used
• Assessment form
• Consent form
• Pen, Pencil, paper
• Chair or exercise mat, couch
• Pillow
• Cotton, Sanitizer
• Electrode gel

Apparatus used
• RMS relax 701 device
• PFT device (HELIOS 401)
• Treadmills
• Sphygmomanometer
• Stethoscope

Figure- 1 Materials and Apparatus Used in Study

❖ **Outcome Measures:**
➤ **Blood Pressure[2]:**
• Measured at each visit after resting of 5 minutes. Three measurements were taken with 1 minute of rest in between them by using the aneroid sphygmomanometer which was calibrated prior to the measurement.
• Average of the blood pressure was taken into the consideration. BP was taken on first visit on bilateral arm and then average of SBP and DBP was taken as the baseline values.

• Position: Sitting: Arm resting on table with mid-arm at heart level, back supported on chair, legs uncrossed and feet flat on floor
• Systolic BP was noted at first or two Korotkoff sound heard (1st phase) and diastolic BP was noted before disappearance of Korotkoff sound (5th phase)

➤ **Galvanic Skin Response[8]**
• Measured with use of RMS relax 701 device which was calibrated prior to the measurement.
• Procedure:

- Position: sitting on chair with arm supported on pillow
- Electrode placement: B/L index finger and middle finger alternatively to eliminate error.
- Skin preparation: Part was cleaned with spirit. Electrode placed over the index finger and middle finger with use of gel. Measurement was taken for two times on each side and average of them was taken into consideration. GSR were taken at pretreatment when subjects took part in study and post treatment after the completion of study in each group.
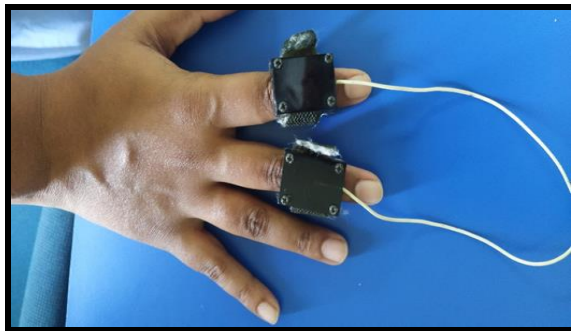- Reliability: Test-retest reliability is 0.75 to 0.96.

Figure- 2 Electrode Placement of GSR Electrode

➢ **Pulmonary function test [9,10,11]**

- Measurement of pulmonary function test was done using computerized PFT machine (Helios 401).
- Procedure of the test was explained to the subjects.
- Position: sitting in chair with feet supported on floor. Nose clip was used appropriately.
- Subjects were asked to perform the FVC maneuver. They were asked to perform the test for 3 times and best test values was taken into the consideration. They were given proper rest in between the maneuver.

➢ Depression, anxiety and stress scale (DASS 21)[12,13]

- Used to determine the level of depression, anxiety and stress in individual with hypertension.

- Reliability of DASS-21 showed that it has excellent Cronbach's alpha values of 0.81, 0.89 and 0.78 for the subscales of depressive, anxiety and stress respectively.

Procedure

- Ethical clearance was taken from the ethical committee.
- All subjects were assessed as per the assessment format. Those who fulfilled all criteria were included in the study. A written informed consent of all subjects was taken. The procedure of intervention was explained to the subjects.
- The duration of treatment was of 4 weeks. After screening of 30 subjects 24 subjects were included in the study.
- There were 11 subjects in the experimental group and 10 subjects in Control group.
- 21 subjects had completed the study and there were 3 dropouts.
- BP, GSR, FVC, $FEV1_1$, and DASS-21 were used as outcome measure which were taken at the pre and post intervention.
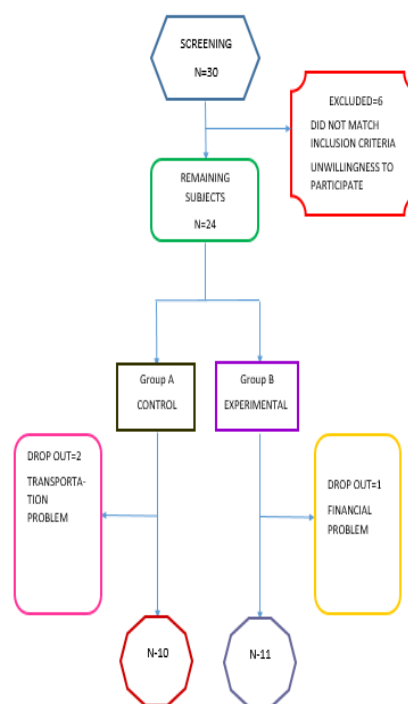

Figure- 3 Flowchart of Methodology

Group A: Aerobic Exercise

Before administration of the treatment the subjects were assessed with the 6 minute walk test (6 MWT) to determine the predict peak HR. It consists of walking for the 6 minutes and cover the maximum distance.

Target HR (THR) = [(HRmax - HRrest) * % of required intensity] + HRrest

Aerobic exercise programme consists of the treadmill walking at a moderate intensity.

Frequency: Aerobic exercise for 3 days per week for 4 weeks.[14]

Intensity: Moderate intensity aerobic exercise [RPE 12- 13 on 6-20 scale.] with HR monitoring continuously while the training.

Duration: Each session was consisted of the 30 minute of training including of 5 minutes of warm up, aerobic exercise period and 5 minutes of cool down.

Mode: continuous Aerobic training was given in form of treadmill walking, warm up and cool down which comprises of the active movements of limbs, stretching exercise.

Subjects were asked to report if there is any discomfort during the treatment.

Figure- 4 Aerobic Training

Group B: Diaphragmatic Breathing + Aerobic Exercise

In this experimental group the protocol of diaphragmatic breathing is added along with the aerobic exercise. In this group protocol of aerobic exercise was same as of the control group protocol. This was carried out when the subjects were relaxed. In addition to the breathing pattern, relaxation of the mind and concentration on the act of breathing were emphasized. The subjects were taught to carry out this act of breathing at six respiratory cycles per min. In the beginning, the subjects were asked to rest for 5 min in the supine position. Then they were performed the exercise in the Semi-Fowler position. Next, the subjects were asked to place their right hand on their chest and left hand below the anterior costal margin. Subjects were asked to breathe in slowly and deeply through the nose, with the shoulders relaxed and upper chest and allowing the abdomen to rise. The subjects were told to slowly let all the air out using controlled expiration. The subject's left hand rise during inspiration and fall during expiration, whereas the right hand remained still. Precautions were taken to avoid hyperventilation. Treatment was given to the once in day with two sets per day each set consists of 6 breath/min. Treatment duration was of 4 weeks.[15, 16]

Figure- 5 Diaphragmatic Breathing Exercise

RESULTS

All the outcome measures were analyzed at the end of the 4 week of the treatment. Prior to the statistical analysis data were screened for normal distribution and baseline differences. Within group analysis and between group analyses was done using the baseline outcome measure before intervention and after the 4 week of intervention. Level of significance was at 5% with confidence interval (CI) at 95%.

Table 1 shows baseline distribution the all outcome measures which shows no statistical significant difference was found (p>0.05) which suggests the all the parameters were same at the baseline.

Table-1 Baseline characteristics

Baseline characteristics	U value	p value
Age	44.5	0.48
Height	45	0.50
Weight	24.5	0.03
BMI	23	0.02
SBP	55	0.96
DBP	53.5	0.94
GSR	50	0.74
FVC	41	0.34
FEV_1	27.5	0.05

Table 2 shows gender distribution of subjects in two groups. There was female predominance in all two groups.

Table 2 Gender Distribution

Gender	Group a	Group b
No. Of females	7	9
No.of males	3	2
Total	10	11

Data were screened for normal distribution which shows outcome measures blood pressure and DASS-21 were normally distributed and GSR, FVC and FEV1 were not normally distributed.

Table 3 shows within group analysis for blood pressure done by using paired t test which showed significant difference was found in pre and post intervention ($p < 0.05$).

Table 3 Mean Changes in Systolic Blood Pressure in Both Groups

Group	Pre value means± SD (mm Hg)	Post value means± SD (mm Hg)	P- value
Group A	133.2 ± 13.10	128.8 ± 13.86	0.012
Group B	133.09 ± 15.73	125.81 ± 16.45	0.0004

Table 4 Mean Changes in Diastolic Blood Pressure in Both Groups

Group	Pre value means± SD (mm Hg)	Post value means± SD (mm Hg)	P- value
Group A	84.8± 4.54	80 ± 6.18	0.001
Group B	85.27 ± 6.34	79.81 ± 7.92	0.0001

Table 5 shows Between groups analysis for blood pressure was done using unpaired t test which showed no significant difference was found in between groups($p>0.05$).

Table 5 Between Group Comparison of blood pressure

Variable	Group A means± SD (mm Hg)	Group B means± SD (mm Hg)	T value	P value
SBP	128.8 ± 13.86	125.81 ± 16.45	2.09	0.66
DBP	80 ± 6.18	79.81 ± 7.92	2.09	0.95

Table 6 shows within group analysis for GSR done by using Wilcoxon Signed-Rank test which showed significant difference was found in pre and post intervention ($p < 0.05$).

Table 6 Mean Changes in Galvanic Skin Response in Both Groups

Group	Pre value means± SD (kilo ohm)	Post value means± SD (kilo ohm)	Z- value	P- value
Group A	128.6 ± 56.20	137.7 ± 58.05	2.80	0.005
Group B	127.18 ± 54.67	167.09 ± 49.11	2.93	0.003

Table 7 shows Between groups analysis for GSR was done using Mann- Whitney signed rank test which showed no significant difference was found in between groups($p>0.05$).

Table 7 between group comparisons of GSR

Difference in GSR	Group A	Group B	Z value	U value	P value
Means	137.7	167.09	1.44	34	0.14
SD	58.05	49.11			

Table 8 and 9 shows within group analysis for FVC, FEV_1 done by using Wilcoxon Signed-Rank test which showed significant difference was found in pre and post intervention ($p < 0.05$).

Table 8 Mean Changes in FVC% in Both Groups

Group	Pre value FVC % Means± SD	Post value FVC % Means± SD	Z- VALUE	P- VALUE
Group A	73.2 ± 10.49	78.1 ± 11.50	2.80	0.005
Group B	77.36 ± 11.29	97.63 ± 7.77	2.93	0.003

Table 9 Mean Changes in FEV_1 % in Both Groups

Group	Pre value FEV_1 % Means± SD	Post value FEV_1 % Means± SD	Z- VALUE	P- VALUE
Group A	77 ± 10.89	79.7 ± 11.04	2.80	0.005
Group B	87.45 ± 14.68	100.90 ± 15.74	2.93	0.003

Table 10 shows Between groups analysis for FVC, FEV_1 was done using Mann- Whitney signed rank test which showed significant difference was found in between groups($p<0.05$).

Table 10 between group comparisons of FVC, FEV_1

Variable	Group A Means± SD	Group B Means± SD	Z value	U value	P value
FVC%	78.1 ± 11.50	97.63 ± 7.77	3.20	9	0.01
FEV1%	79.7 ± 11.04	100.90 ± 15.74	2.81	14.5	0.04

Table 11 shows within group analysis for DASS-21 done by using paired t test which showed significant difference was found in pre and post intervention ($p < 0.05$).

Table 11 Mean Changes in DASS- 21 Score In Both Groups

Group		Pre value means± SD	Post value means± SD	P value
Group A	D	0.7 ± 0.67	2.2 ± 0.42	0.09
	A	0.8 ± 0.56	0.4 ± 0.51	0.01
	S	2.72 ± 1.08	0.5 ± 0.69	0.01
Group B	D	0.5 ± 0.68	0.09 ± 0.3	0.01
	A	1 ± 0.63	0.09 ± 0.3	0.0002
	S	2.16 ± 0.98	0.54 ± 0.68	0.001

Table 12 shows between groups analysis for DASS-21 was done using Mann- Whitney signed rank test which showed no significant difference was found in between groups($p>0.05$).

Table 12 between Group Comparisons of DASS 21

Variable	Group A	Group B	T value	P value
Depression	0.2 ± 0.4	0.09 ± 0.3	1.22	0.1
Anxiety	0.4 ± 0.5	0.09 ± 0.3	1.69	0.1
Stress	2.72 ± 0.5	0.5 ± 0.6	0.18	0.8

DISCUSSION

Present study was conducted to determine the additive effects of diaphragmatic breathing on hypertensive people on BP, GSR, FVC, FEV_1 and DASS-21. In that SBP, DBP, GSR, FVC and FEV_1 was improved post training as compare to pre training in both groups which was statistically significant ($p < 0.05$). There was no statistical significant difference found when between groups analysis was done in SBP, DBP, GSR and DASS-21 ($p > 0.05$) in control group compared to experimental group. There was significant statistical difference found when between groups analysis was done in FVC and FEV_1 ($p < 0.05$) in control group compared to experimental group.

As per the result of this study effects of aerobic exercise helps in the reduction of the blood pressure which is also mentioned in previous narrative reviews and meta-

analysis that showed the relationship between exercise and blood pressure that is by Reduction of peripheral resistance, sympathetic activity, plasma levels of norepinephrine and cardiac output have been associated with reduction of blood pressure following exercise.

Effects of the improving in the FVC and FEV$_1$ parameters followed by the aerobic exercise was seen in the study which is also supported by the Angane et al 2016 and Shashikala et al 2011.the mechanism by which it works is due to strengthening of the inspiratory muscles.[17,18]

Present study stated that there was a significant difference was found in the experimental group in which the diaphragmatic breathing exercise was added along with the aerobic exercise which shows a significant increase in the galvanic skin response post intervention which is supported by previous studies conducted by Dhodi et al 2014 and Adhana et al 2011 which due to the beneficial effects on the autonomic nervous system.[19]

Present study also showed significant difference was found post intervention in experimental group hence diaphragmatic breathing helps in reduction of the blood pressure along with the aerobic exercise possible mechanism is described by the Lovikali et al 2017 and Kaur et al 2015 showed that can be due to breathing exercise increases baroreflex sensitivity and reduces sympathetic activity which led to the reduction in the blood pressure.[20, 21]

CONCLUSION

Present study concluded that Diaphragmatic breathing along with the aerobic exercise has significant effects on FVC and FEV$_1$ however there were no additional significant effects found on BP, GSR and DASS-21.

Future Scope of the Study

Further studied can be done on isolated effects of diaphragmatic breathing.

Further studies can be done in comparison with the conventional treatment of hypertension.

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