ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 5, Issue 12, December 2020

A Systematic Review And Meta-Analysis Of Effectiveness Of Breathing Exercises On Blood Pressure Of Patients With Hypertension

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***Abstract*— Background and aims: Hypertension is one of the most dreaded diseases of the human kind. It is not only a risk factor for many other diseases but also the reason for plenty of complications. Relaxation techniques like Breathing Exercises have an impact on Blood pressure of patients with hypertension and are backed by various researches. The aim of present research was to estimate the efficacy of Breathing Exercises in lowering the BP of patients with hypertension. Breathing exercises considered for this review are non device guided and are specifically aimed at increasing the oxygen concentration in the body different from meditation and bio-feedback. This research is a systematic review and meta- analysis to understand the efficacy of these therapies in hypertension. Results: A comprehensive electronic and manual search with a broad strategy yielded a total of 9 studies as per inclusion exclusion criteria. Data was extracted and studies were assessed for methodological quality. It was seen that the breathing exercises were effective in reducing Blood pressure. Conclusions: The findings suggest that Breathing Exercises had a positive and significant effect on BP of hypertensive individuals.**

***Keywords*— Meta-Analysis, Breathing Exercises, Blood Pressure, Hypertension**

I. INTRODUCTION

Non-communicable diseases are one of the most dreaded diseases of the human kind. Many of the key-facts given by WHO reveal that these diseases kill almost 41 million every year (1). Hypertension is one such disease which is associated with varied extreme mortality and morbidity related to the compilations associated with it. This disease is even more problematic as it shows symptoms in quite later stages and this can trigger immense damage in a short period of time. Currently, about 26% of world population (about 972 million) has hypertension, and this can increase to 29% by 2025, with great onus on the developing nations (2). Mills, K and etal ,2020 (3) studied the global epidemiology of hypertension by analyzing data from 844 studies of 154 nations and found that high mean systolic and diastolic Blood pressure is raised in regions of South Asia ,Africa and parts of Europe.

Hypertension or High Blood Pressure is often called the "silent killer". It is a disease associated with rise in systolic BP above 120 mm Hg and diastolic BP above 80 mm Hg as measured by the BP instrument (4). This chronic elevation is also cause for many complications and future health problems. This disease requires life long dependence on medications and health care, thus, escalating the health care costs for these patients much higher than one could afford. Hence, there is need to find out the most effective and cost-efficient strategies for tackling this condition so that one is freed from all the problems associated with this disease.

Current research has yielded that various complementary therapies have a huge impact on not only lowering high blood pressure but also relieving variety of complications due to hypertension (5). The is evidence for music, relaxation, exercise , diet, mind-body therapies and so on for lowering the blood pressure in the patients with hypertension. Breathing exercises are seen to be effective in lowering the blood pressure of patients with hypertension. The Breathing exercises can be conducted in various ways, they could be given alone or coupled with other complementary therapies of music, relaxation, biofeedback or meditation for gaining the desired results for patients with hypertension. They could be device aided or practiced as kriyas or as a simple process of inhalation and exhalation. However, to know the actual impact of breathing exercises we need to consider the breathing practices alone as a process of inhalation and exhalation where the patient just concentrates on his respiration exclusive of meditative, music, mind body therapies, biofeedback or other complementary therapies. Much of the research has been

conducted regarding the device aided breathing or breathing coupled with other sorts of complementary therapies, and a review specific to the breathing techniques itself is quite limited. Hence, in this systematic review and meta-analysis we have tried to generate the evidence on the effectiveness of breathing exercises on systolic and diastolic blood pressure of patients with hypertension.

II. METHODS

Protocol development and registration

The Protocol was registered with PROSPERO with registration number CRD42020134537.

Search strategy

For breathing exercises the literature was searched using the following strategy: hypertension, "blood pressure*", "high blood pressure*" AND breathing exercise*, pranayam*, breathing NOT pregnan*, NOT gestational, NOT preeclampsia, NOT pre-eclampsia , NOT pregnancy induced hypertension.

Eligibility criteria:

Types of studies and their selection:

Inclusion criteria: True experimental studies and quasi-experimental research studies with Pretest and Post test control group design, in English language, Published in a peer reviewed journal between 2008-2018.

Exclusion criteria: Cross-sectional/longitudinal studies, Ongoing studies, unpublished articles, conference proceedings, case series studies and abstracts/ posters

Types of Participants

Inclusion criteria: Adults with mean age of 18 years and above (both male and female) , Hypertensive (Systolic BP above 140 and diastolic BP above 90 mm Hg i.e. stage 1 and stage 2 hypertension patients) or hypertension along-with other associated diseases

Exclusion criteria: Adults with gross medical or surgical illness or psychopathology, Pregnant women

Types of Interventions

Inclusion criteria: Breathing Exercises in experimental group , Control group receives other intervention of physical training like walking, jogging, exercise, other interventions like routine nursing care, education, or "no intervention".

Exclusion criteria: Studies with multiple interventions or without control group.

Types of Outcome Measures

Reduction in Systolic BP (SBP), Reduction in Diastolic Blood Pressure (DBP)

III. LITERATURE SEARCH:

Data Sources:

Systematic search for studies was conducted in databases of PUBMED/MEDLINE, AMED (OVID) , CINAHL Plus ,Cochrane CENTRAL, PsycINFO ,ScienceDirect ,Scopus, JSTOR ,ProQuest and Google Scholar published between 2008-2018.

Data Collection:

Search strategy was applied to all databases. The results were downloaded as BIBTEX (bibliography and typesetting software) or RIS (Research Information Systems) format. Mendeley reference management system was used for deduplication and maintaining the references. One reviewer (PhD scholar) independently extracted the study data and it was then checked by the guide and any discrepancies/disagreements were sorted out.

Data Extraction:

The relevant data was extracted to in the categories of First Author's name, Gender, Duration of Illness, Age of participants, Sample size, Changes in the stress level (before and after intervention), Changes in the Systolic BP (before and after intervention), Changes in the Diastolic BP (before and after intervention) .Any missing information was enquired from the respective authors.

IV. LITERATURE QUALITY EVALUATION

Risk of Bias Assessment:

The methodological quality of the studies was analyzed by Cochrane Risk of bias tool for Randomized studies and Risk Of Bias In Non-randomized Studies - of Interventions tool for Quasi-randomized studies. Most of the randomized studies were found to have moderate quality while most of the quasi-experimental studies were found to have low quality. But all of the studies were included in further analysis i.e. quantitative synthesis or meta-analysis. Fig 1 and 2 gives the Risk of Bias assessment.

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International Journal of Science, Engineering and Management (IJSEM)
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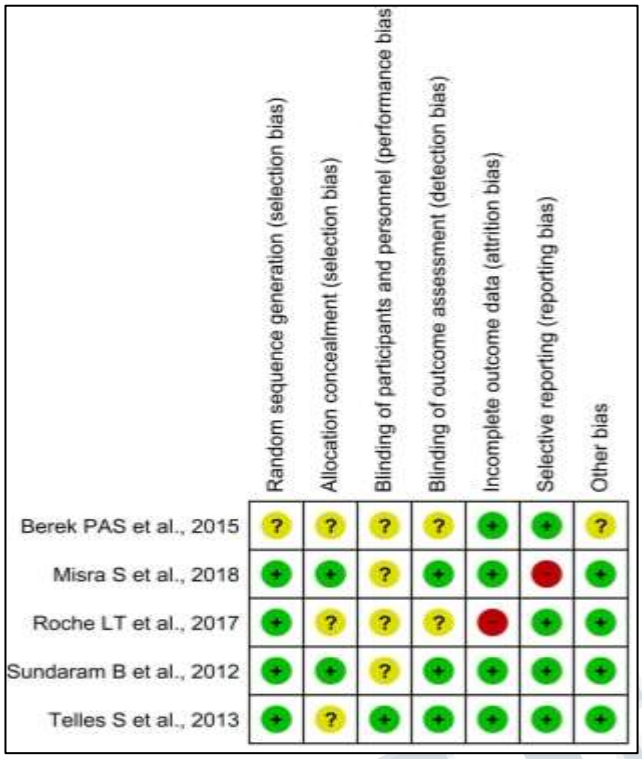

Fig 1a:Risk of Bias summary for RCTs of Breathing Exercises

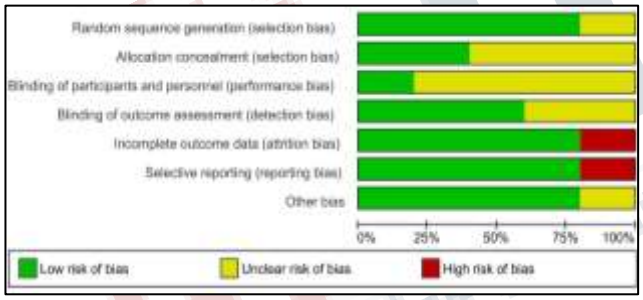

Fig 1b:Risk of Bias summary for RCTs of Breathing Exercises

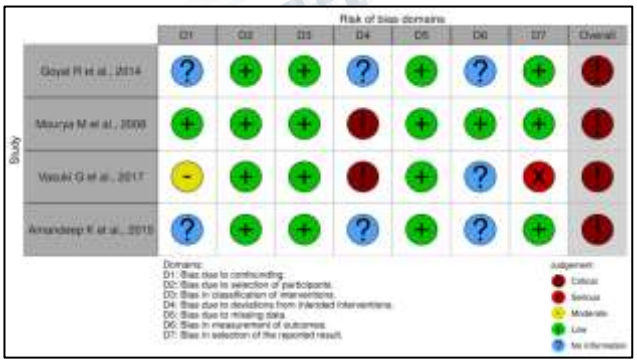

Fig 2a:Risk of Bias summary for Quasi-experimental studies of Breathing Exercises

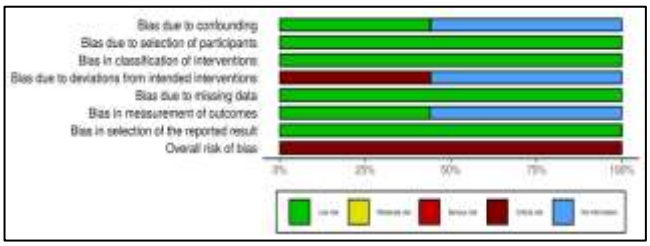

Fig 2b:Risk of Bias graph for Quasi-experimental studies of Breathing Exercises

Statistical Analysis

The Cochrane REVAMAN 5 software was utilized for the purpose of meta-analyzing the studies with the production of forest plots. Since, the studies were less than 10 , the funnel plot was not attempted to find out publication bias.

V. RESULTS

Literature retrieval situation:

Initially, a broad based search was applied with a sole limitation of year range of 2008-2018. A total of 1,29,800 citations were retrieved and after deduplication 68251 records remained. Out of this only 33 were retained after title abstract check. Thereafter only 9 articles were chosen after full paper search was done as per inclusion and exclusion criteria (Fig 3).

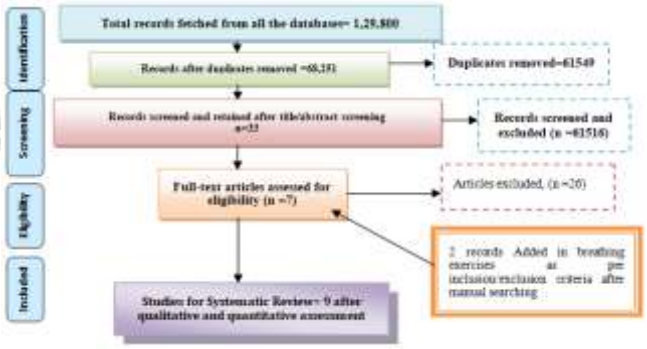

Fig 3: Studies included in Meta-analysis after Systematic review

Characteristics of Included studies

Characteristics of Included studies for Breathing Exercises has been represented in Table 1. Total sample size was 640, majority of studies ha participants between ages of 20 to 60 years, males constituted 53% of the enrolled patients, most studies had study duration of 5 to 10 weeks (34%) ,many of studies were Randomized controlled trials. Most often reported outcome was Systolic BP while Diastolic BP was not reported in few studies. The excluded studies have been represented In Table 2.

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International Journal of Science, Engineering and Management (IJSEM)
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Effectiveness of Breathing Exercises on Systolic BP (SBP)

Random-effects meta-analysis involved 454 patients. The meta-analysis of comparison of Experimental and control group showed decrease in pooled mean SBP of -10.27 mm Hg [95% CI: -14.44, -6.09]. The test of overall effect Z =4.82, P < 0.00001 highly statistically significant. The Forest Plot generated for the effect is given in Fig 4. The studies showed change in SBP towards the negative side of effect size axis and the overall effect favored Breathing Exercises. It was concluded that the Breathing exercises were effective in decreasing Systolic BP as compared to control. The test for Heterogeneity revealed I^2 to be 92% which high and a subgroup analysis was done to understand the reasons for heterogeneity.

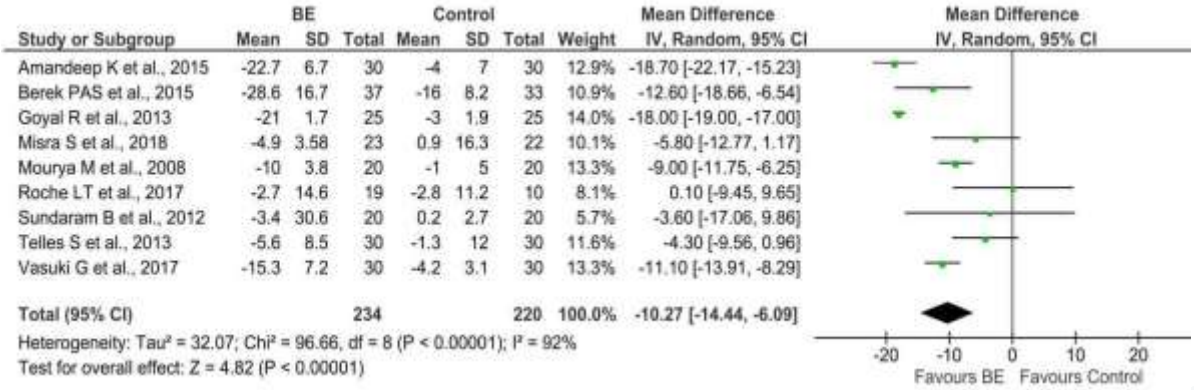

Fig 4: Forest Plot comparing changes in SBP in Experimental group compared to Control Group for Breathing Exercises studies

Effectiveness of Breathing Exercises on Diastolic BP (DBP)

7 studies were included in random-effects meta-analysis involving 359 patients. A random-effects meta-analysis of comparison of Experimental and control group showed decrease in pooled mean DBP of -6.74 mm Hg [95% CI: -9.95, -3.52]. The test of overall effect Z =4.10, P <0.0001 which was highly significant. The Forest Plot generated for the effect is given in Fig 5. Breathing exercises were hence, effective in decreasing Diastolic BP in experimental group as compared to control. The test for Heterogeneity revealed I^2 to be 95% and a subgroup analysis was done to understand the reasons for heterogeneity.

Table 1 Characteristics of the Included Studies for Breathing Exercises

Study	Study Design	Groups	N	Age	Men	Study duration	Pretest SBP	Posttest SBP	Pretest DBP	Posttest DBP	Pretest Stress score	Posttest Stress score
Telles S et al., 2013(6)	RCT	Anuloma-viloma	30	49.7 (9.5, 20-59)	NR	10 minutes	133.67 (14.26)	128.00 (±10.64)	85.67 (8.58)	84.33 (7.28)	NA	NA
		Breath awareness	30	49.7 (9.5, 20-59)	NR		130.67 (16.39)	127.20 (13.72)	84.33 (10.73)	83.73 (9.26)	NA	NA
		Reading a magazine	30	49.7 (9.5, 20-59)	NR		140.83 (14.22)	139.53 (18.65)	81.20 (9.42)	81.33 (9.37)	NA	NA
Roche LT et al., 2017(7)	RCT	Himalayan Tradition (HT) Meditation	25	59.42 (9.88)	2(16.66%)	8 weeks/ 2 Months	NR	NR	NR	NR	NR	NR
		Pranayama group	25	60.95 (8.38)	8(42.11%)		133.42 (16.71)	130.79(22.23)	81.77 (12.04)	84.63 (11.21)	27.95 (7.1)	19.79 (6.67)
		Yoga Practice group	25	54.14 (9.65)	5 (35.71%)		NR	NR	NR	NR	NR	NR
		Control group	25	54.40 (8.92)	5(50%)		133.4 (15.79)	130.6 (19,31)	80.3 (12.55)	83.3 (15.5)	26.3 (6.07)	28.1 (5.08)

Misra S et al., 2018 (8)	RCT	In class group	23	59.6 (13.1)	13 (57%)	10 weeks	155.4 (15.9)	150.5 (16.3)	NR	NR	NA	NA
		Youtube/DVD group	38	62.8 (10.1)	20 (53%)		152.5 (15.5)	145.3 (11.7)	NR	NR	NA	NA
		Control group	22	58.6 (12.0)	10 (46%)		149.2 (23.7)	150.1 (17.2)	NR	NR	NA	NA
Sundaram Beta.,2012 (9)	RCT	Slow Breathing Excercise group	20	53.00 (5.40)	12 (60%)	4 weeks/	140.10 (7.4)	136.70 (5.39)	84.50 (6.79)	80.5 (5.9)	NA	NA
		Control group	20	52.15 (4.58)	14 (70%)		139.50 (6.51)	139.70 (5.92)	83.40 (5.54)	84.20 (4.80)	NA	NA
Goyal R et al., 2013(10)	Quasi-experimental	Test group	25	46 (0.85)	16 (64%)	6 Weeks	148 (1.62)	127 (2.42)	NA	NA	NA	NA
		Control group	25	46 (1.11)	15 (60%)	6 Weeks	144 (1.41)	141 (2.41)	NA	NA	NA	NA
Mourya M et al., 2008(11)	Quasi-experimental	without intervention	20	NR	12 (60%)	3 Months	146 (2.43)	145 (5.56)	90.7 (1.98)	90.7 (2.41)	NA	NA
		Slow breathing exercise	20	NR	10 (50%)	3 Months	144 (3.48)	134 (5.15)	91.6 (2.19)	84.6 (2.41)	NA	NA
		Fast breathing exercise	20	NR	9 (45%)	3 Months	146 (2.43)	143 (5.34)	90.7 (1.98)	89.6 (2.45)	NA	NA
Vasuki G et al., 2017(12)	Quasi - experimental	Control group	30	46 (4.2)	NR	Week 12	148 (8.42)	143.8 (7.8)	90 (10.2)	87.5 (8)	NA	NA
		Breathing exercise	30	47 (4.2)	NR		139.1 (14)	123.8 (6.5)	91.7(9.4)	80.3 (4.4)	NA	NA
Kaur, A et al., 2015(13)	Quasi-experimental	Breathing exercise	30	47.7 (10.56)	15 (50%)	11 days	158.2 (8.69)	135.53 (5.39)	105.93 (8.19)	89.26(4.15)	NA	NA
		Control group		50.76 (9.8)	16(26.7)		153.26(10.23)	149,2(7.4 9)	101.33 (8.19)	100.33 (7.1)	NA	NA
Berek PAS et al., 2015(14)	Quasi-experimental	Slow deep breathing	37	48.81 (10.01)	NR	2 weeks	157.65 (17.69)	129.05 (5.80)	99.84 (7.94)	82.92 (5.22)	NA	NA
		Control group	33	51.03 (10.09)	NR		163.70 (12.36)	147.70 (9.23)	99.70 (8.05)	90.45 (7.61)	NA	NA
		Low salt diet (LS)	33	47.97 (13.61)	NR		159.09 (14.19)	135.00 (9.08)	97.58 (9.67)	85.18 (4.62)	NA	NA
		Both SDB+LS	39	48.46 (7.28)	NR		161.41 (15.350	137.46 (9.61)	99.97 (12.13)	88.97 (6.47)	NA	NA

Table 2 Excluded Studies for Breathing Exercises with reasons

Sno	Authors	Reason for exclusion
1	Dileep, S and Doss, J , 2016 (15)	Contacted regarding inclusion criteria of Hypertensive patients, No reply
2	Santhong, B and et al , 2016(16)	The treatment of unloaded breathing was through a device , not as per inclusion criteria
3	Niranjan, M and et al , 2009(17)	Multiple Interventions in the yoga group consisting of breathing, asanas, om chanting
4	Roche, LT and Hesse, B.M. , 2014(18)	Multiple Interventions in the yoga group consisting of yoga positions and breathing techniques
5	Sangprasert, P and et al ,2018(19)	Multiple Interventions in experimental group of breathing, mindfulness and conversation
6	Jones, C and et al , 2010(20)	The treatment of unloaded breathing was through a device , not as per inclusion criteria
7	Sujatha and Mohanraj, J , 2013(21)	Multiple Interventions in experimental group of breathing, yoga asnas, meditation
8	Shetty ,P and et al , 2017 (22)	Patients were Pre-hypertensive not as per inclusion criteria

9	Anderson, E , 2017 (23)	Mixed patients of pre-hypertension, hypertension grade-1 and grade 2
10	Satyanand, V and et al , 2016 (24)	Multiple Interventions in experimental group of pranayama and asanas
11	Sitre, S and Wasu, Y , 2011 (25)	Multiple Interventions in experimental group of pranayama and asanas
12	Janet, K.S. and Gowri, P.M. , 2017 (26)	BP of patients not as per inclusion criteria
13	Cramer, H and et al , 2018 (27)	Multiple interventions in group without yoga postures of only breathing, meditation, relaxation ,short presentations, and question-answer
14	Kumari, S and et al , 2015 (28)	Some additional information about inclusion/exclusion criteria was required but no email id was given for contacting
15	Mizuno,M. and Monteiro, H.L. , 2012 (29)	Multiple Interventions in experimental group of pranayama and asanas
16	Punita, P and et al ,2016 (30)	Multiple Interventions in experimental group of pranayama , prayer and asanas
17	Dabbu, S and et al , 2012 (31)	Multiple Interventions in experimental group of pranayama and asanas
18	Yusiana,M.A. and Suwardianto , H ,2014 (32)	Article in Indonesian language
19	Patil, S.G. and et al ,2014 (32)	Multiple Interventions in experimental group of pranayama , prayer and asanas
20	Bahmani, S.D. and et al, 2018 (33)	poster presentation
21	Chinnarani, M.A. , 2018 (34)	Unpublished Dissertation
22	Elavarasi. R ,2018 (35)	Inclusion criteria for hypertensive patients was not given and no email provided for contact
23	Kulal, R, 2017 (36)	Intervention consists of pranayama, savasana and sukhasana
24	Narayanan,M and Elangovan, R, 2017 (37)	Intervention consists of Kundalini Yoga
25	Prakash, S. and Gupta, R ,2015 (38)	Multiple Interventions in experimental group of pranayama and asanas
26	Kumari, R and et al, 2018 (39)	Inclusion criteria for hypertensive patients was not given, emailed and no reply received

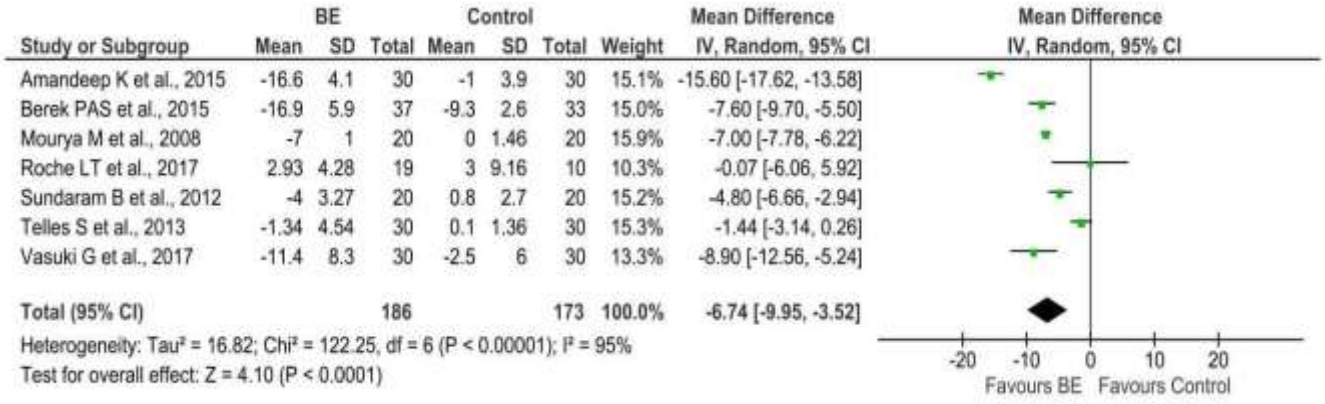

Fig 5: Forest Plot comparing changes in DBP in Experimental group compared to Control Group for Breathing Exercises

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Subgroup analysis for Systolic BP

The subgroup analysis for systolic BP was conducted for all the moderator variables reported in the studies. It was seen that the Breathing exercises significantly decreased SBP in the Study design of Quasi-experimental (P=0.01) for which effect was also higher. All other moderators of Gender, Geographical location, study duration and duration of intervention did not modify the effect of breathing exercises on Systolic BP of patients with hypertension. Table 3 and Figs 6 illustrate the subgroup analyses for systolic BP.

Table 3:Results of Subgroup analysis for effects on SBP after Breathing exercises

Subgroup Category	Number of Trials	Effect size	Heterogeneity	p
Gender :				
More Males	6	-11.46 (-16.34,-6.57)	I^2 =91%	0.49
More females	2	-6.81 (-19.21,-5.59)	I^2 =90%	
Geographical Location:				
India	6	-11.79 (-16.56,-7.01)	I^2 =93%	0.25
Outside India	3	-6.82 (-13.80,0.16)	I^2 =92%	
Study design:			I^2 =39%	
RCT	5	-6.06 (-10.34,-1.77)		0.01*
Quasi-experimental	4	-14.22 (-19.10,-9.35)	I^2 =94%	
Study duration:				
Less than 7 weeks	5	-12.07 (-17.99,-6.14)	I^2 =91%	0.30
More than 7 weeks	4	-8.47 (-11.66,-5.28)	I^2 =52%	
Duration of Intervention:				
30 minutes or less	5	-10.18 (-14.76,-5.59)	I^2 =86%	0.62
More than 30 minutes	4	-6.81 (-19.21,-5.59)	I^2 =79%	

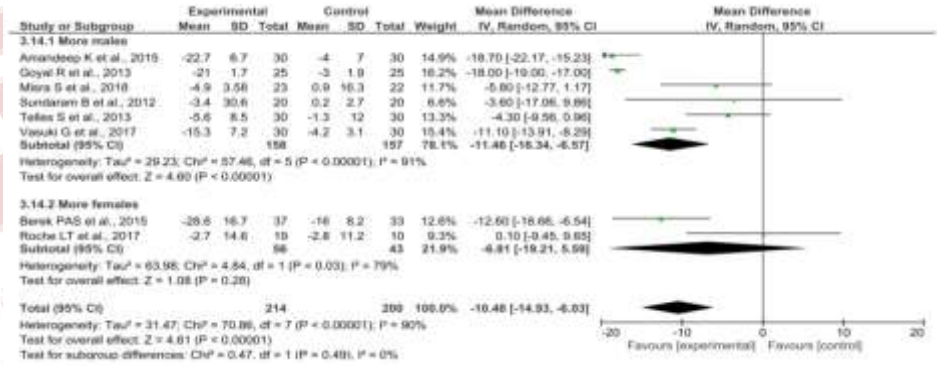

Fig a

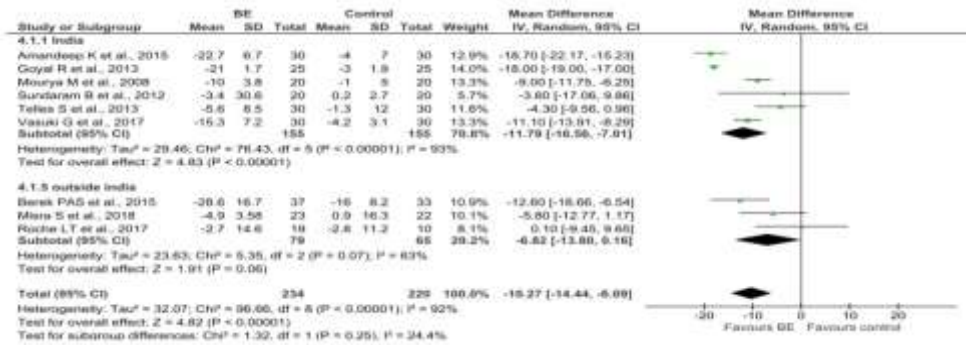

Fig b

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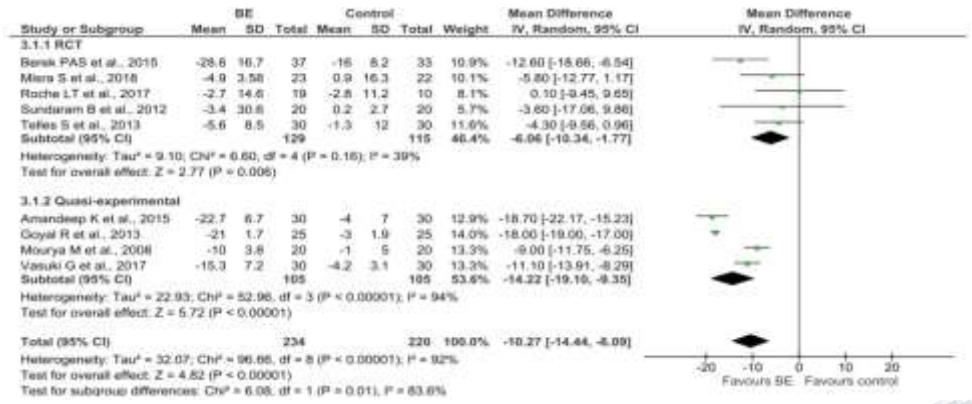

Fig C

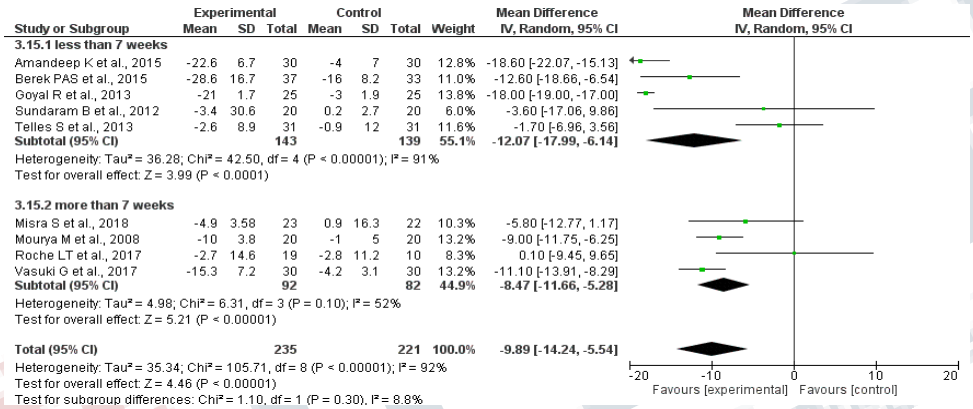

Fig d

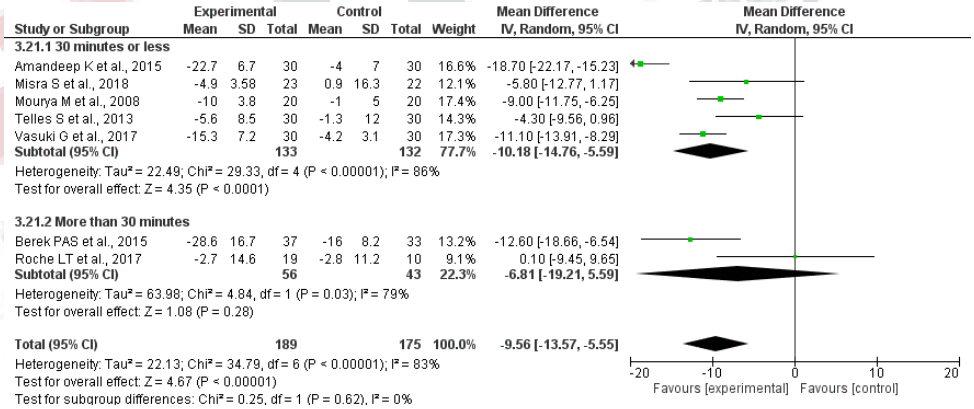

Fig e

Fig 6 Forest Plots of subgroup effect of Breathing exercises on Systolic BP in hypertension (a) Gender (b) Geographical Location (c) Study design (d) Study duration (e) Duration of Intervention

Subgroup analysis for Diastolic BP(DBP)

The subgroup analysis for diastolic BP was conducted for all the moderator variables reported in the studies. It was seen that the Breathing exercises significantly decreased DBP in the Study design of Quasi-experimental (P=0.06) for which effect was also higher. All other moderators of Gender, Geographical location, study duration and duration of intervention did not modify the effect of breathing exercises on Diastolic BP of patients with hypertension. Table 4 and Figs 7 illustrate the subgroup analyses for diastolic BP.

Subgroup Category	Number of Trials	Effect size	Heterogeneity	p
Gender :				
More Males	4	-7.18 (-11.82,-2.55)	I^2 =97%	0.53
More females	2	-4.38 (-11.68,2.92)	I^2 =96%	
Geographical Location:				
India	5	-6.96 (-11.75,-2.18)	I^2 =98%	0.56
Outside India	2	-4.38 (-11.68,2.92)	I^2 =81%	
Study design:				
RCT	5	-3.90 (-7.08,-0.72)	I^2 =87%	0.06**
Quasi-experimental	2	-10.50 (-16.61,-4.40)	I^2 =97%	
Study duration:				
Less than 7 weeks	4	-7.34 (-13.28,-1.41)	I^2 =97%	0.76
More than 7 weeks	3	-6.28 (-9.58,-2.98)	I^2 =68%	
Duration of Intervention:				
30 minutes or less	4	-8.19 (-13.37,-3.01)	I^2 =97%	0.40
More than 30 minutes	2	-4.38 (-11.68,-2.29)	I^2 =81%	

Table 4:Results of Subgroup analysis for effects on DBP after Breathing exercises

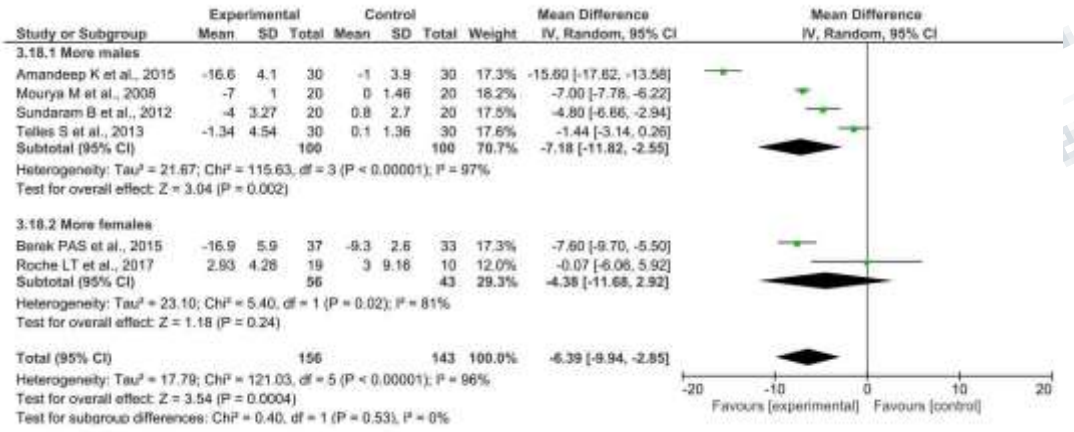

Fig a

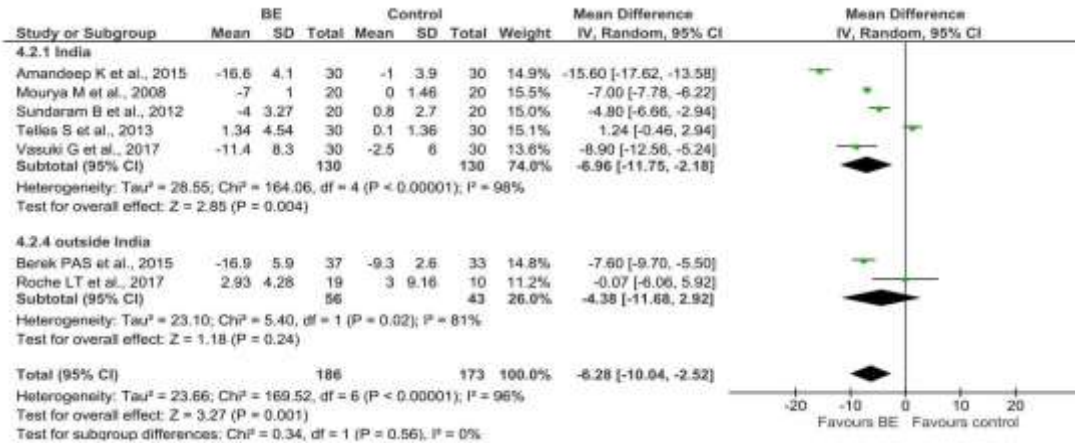

Fig b

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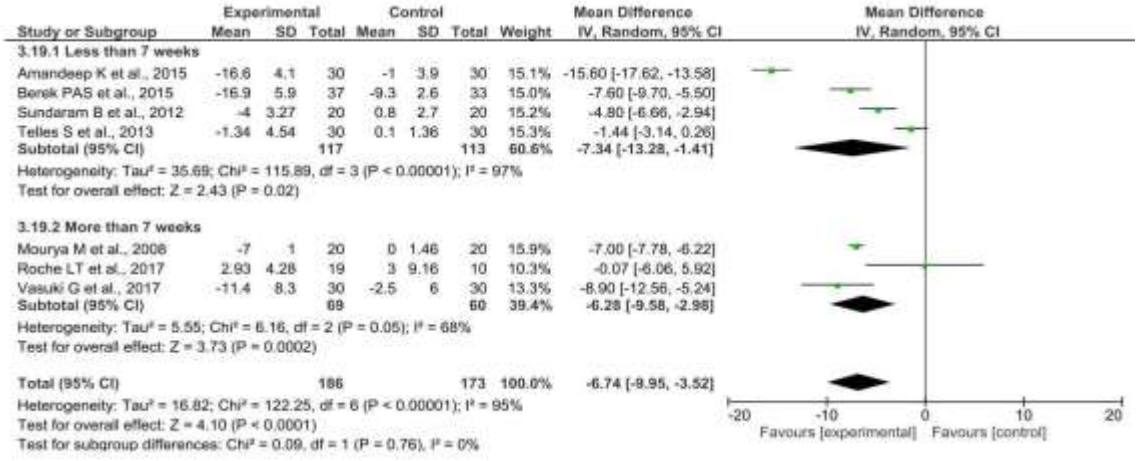

Fig c

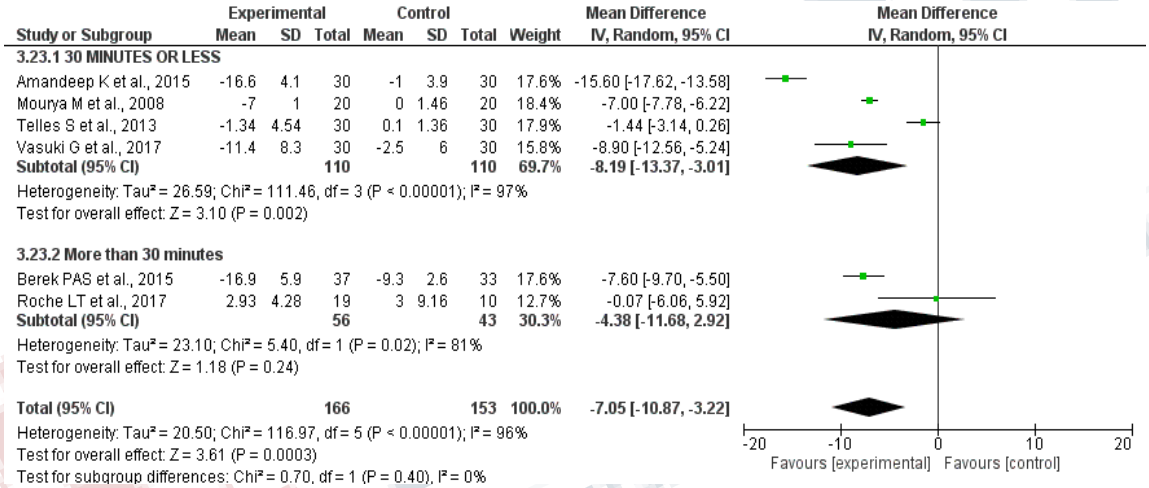

Fig d

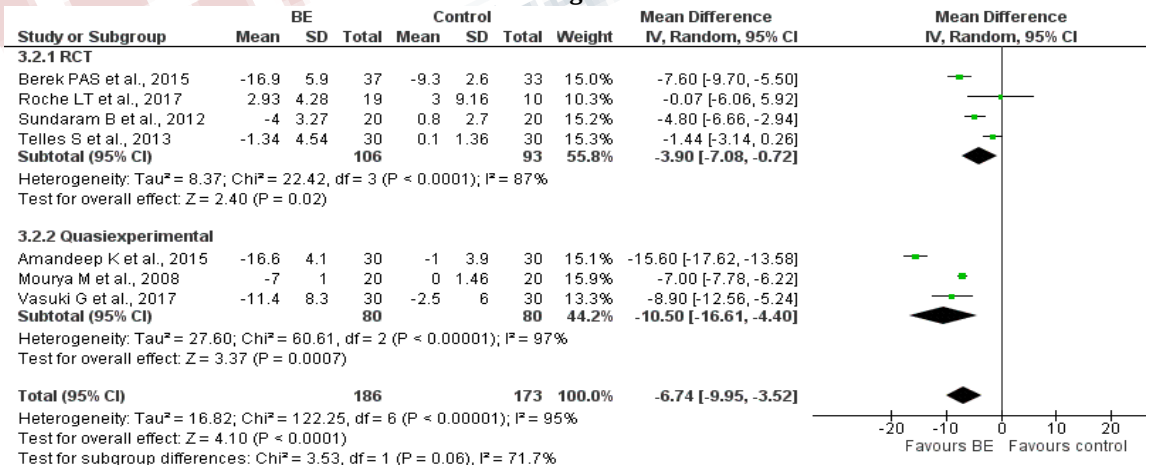

Fig e

Fig 7 Forest Plots of subgroup effect of Breathing exercises on Diastolic BP in hypertension (a) Gender (b) Geographical Location (c) Study design (d) Study duration (e) Duration of Intervention

VI. DISCUSSION

This meta-analysis estimated the efficacy of the breathing exercises and the differences on Systolic and Diastolic BP of patients with hypertension. The results indicated that breathing techniques brought significant reduction in both systolic BP and diastolic BP of patients with hypertension. This meta-analysis is a new attempt to study the effect of purely Breathing exercises on patients with hypertension and the results are similar to those seen in various other meta-analysis involving Breathing Exercises (40-44) for both systolic and diastolic blood pressure unlike one which showed no evidence (44) Since, this a much widely used therapy in variety of researches for patients with hypertension, it is important to be aware of its effectiveness. This is one of the many strengths of this study.

However, in light of moderate to low quality of studies one should approach the results with a certain level of caution. It is also needless to say that the heterogeneity of the studies was quite high. We tried explaining it with much of the sub-group analysis but it could not be explained to much greater detail. The heterogeneity could also be attributed to many factors that have not be rigorously reported in the study like duration of illness, type of antihypertensive drug, ethnicity of the patients, followup and so on. This is one of the limitation of the study.

VII. CONCLUSION

The systematic review and meta-analysis suggests that Breathing exercises are useful in not only decreasing the BP of patients with hypertension and this is also influenced by Study design of the research. It is recommended that much better experimental studies may be conducted so that we can be confident on the results obtained by this research.

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