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EFFECTS OF A SLOW-DEEP BREATHING PROTOCOL ON LOWERING BLOOD PRESSURE: A RAPID REVIEW

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by

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to examine the thesis of Amanda Gravholt

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Effects of a Slow-Deep Breathing Protocol on Lowering Blood Pressure: A Rapid Review

Abstract

Background

Hypertension is a major contributor to high rates of mortality in the United States and around the world. At the same time, the cost of pharmaceuticals continues to increase, and pharmacological noncompliance grows. There is a growing interest in the efficacy of alternative or integrative methods in lowering blood pressure. Regulated, slow deep breathing has been shown to have beneficial effects on blood pressures.

Objectives

The overarching goal of this study was to identify a non-pharmacological, easy to learn method that could be followed by patients in the home setting to control blood pressures. The target population was adults with hypertension. The intervention was a slow deep-breathing protocol or similar variants. The comparison intervention was either pharmacologic treatment or placebo (e.g., simple breathing exercise). The desired outcome was lowered blood pressure. The time frame was left open to see what studies have been completed, both short term and long term. This review set out to find what studies have been done to answer this question: In adults with

hypertension, how does a slow deep-breathing protocol or a similar variant compared with pharmacologic treatment or placebo affect hypertension?

Data Sources

PubMed Central (December 2015 to December 2020) and CINAHLComplete (via EBSCOhost) (December 2015 to December 2020).

Study Eligibility Criteria, Participants, and Interventions

Published articles relating to blood pressure in which a slow-deep breathing intervention was utilized were included in this review. Terms used in place of slow-deep breathing could be "breathing exercises" or "paced breathing". To be included, the articles were required to be peer-reviewed and in the English language.

Study Appraisal & Synthesis Methods

The evidence was synthesized by being placed in seven categories: 1. Support implementation of a slow deep-breathing protocol to reduce blood pressures; 2. Support the implementation but contingent upon further research; 3. Do not support the implementation based on current data but are hopeful for implementation after further studies performed; 4. Do not support the implementation of a protocol or any similar variants; 5. Are hesitant on the implementation; 6. Support an acute protocol, but not long-term; 7. Results are inconclusive.

Results & Limitations

The review found 846 papers, which was reduced to 29 after screening and relevance checks (Diagram 1 for detailed analysis).

Conclusions and Implications of Key Findings

A slow-deep breathing protocol appears to reduce blood pressure in adults with hypertension in the short term. More research is necessary to determine the effects of slow-deep breathing's effect on blood pressure long term.

No review registration number

Introduction

Rationale

Preliminary reports in the literature have indicated that slow deep breathing can be used to regulate blood pressures. However, protocols vary widely and many of the studies were subject to confounding variables that include lifestyle alterations. With this study, an attempt was made to isolate the effects of slow deep breathing from other influences and to define a minimal, standardized breathing protocol.

Objectives

We examined the published literature to answer this PICOT question: In adults with hypertension, how does a slow deep-breathing protocol or a similar variant compared with pharmacologic treatment affect hypertension?

Definition of Terms

Prehypertension (Stage 1 Hypertension): a systolic blood pressure of 130-139 mmHg or a diastolic of 80-89 mmHg

Hypertension (Stage 2): systolic of greater than or equal to 140 mmHg and a diastolic of greater than or equal to 90 mmHg

Loaded Breathing: the imposition of "a workload on the inspiratory muscles, maintains a constant load during inspiration" (Myrrha, Vieira, et al., 2013)

Baseline BP: the BP reading taken during the introductory/consent session

Pre/post BP: the BP reading taken before each breathing protocol and immediately after.

Nonpharmacological: any non-drug treatment used in the treatment of disease processes

Pharmacological: any drug treatment used in the treatment of disease processes

Methods

Protocol and registration

N/A

Eligibility criteria

- Published in peer reviewed journals
- English Language
- Empirical studies utilizing qualitative, quantitative, or mixed methods approaches
- Review articles
- Accessible to students through the USD Library resources as full text

Information sources

A rapid review of articles using PubMed Central (December 2015 to December 2020) and CINAHL Complete (via EBSCOhost) (December 2015 to December 2020).

Search

PubMed:

(("hypertense"[All Fields] OR "hypertension"[MeSH Terms] OR "hypertension"[All Fields] OR "hypertension s"[All Fields] OR "hypertensions"[All Fields] OR "hypertensive"[All Fields] OR "hypertensive s"[All Fields] OR "hypertensives"[All Fields]) AND ("deep breathing"[All Fields] OR ("breathing exercises"[MeSH Terms] OR "breathing exercises"[All Fields]) OR "paced breathing"[All Fields] OR ("slow-deep breathing") OR ("Pranayama"))=325 Results

Published Last 5 years= 71 Results

Full Text Available: 66 Results

Records removed because visual scanning identified key words such as "anxiety and depression", acupuncture, "muscle training", "autonomic dysregulation", Covid, dietary, "earable ZEN", "white-coat effect", diabetic, ocular hypertension, Turner syndrome, migraine, pulmonary hypertension, "traube-hering waves", obese, "passive head-up and -down movement", comorbid, tachycardia, pregnancy, microangiopathy, intracerebral, alcohol, carotid, "obstructive sleep apnea", "metabolic syndrome", "chemoreflex response", asthma, COPD, stroke, stroke risk, tai chi, qigong, "Framingham Risk Score", dialysis

Screening of Titles and Abstracts for Relevance= 21 Results

CINAHL Complete:

[searched December 2015, through December 2020]

Search Strategy: hypertension or high blood pressure or elevated blood pressure or htn or hypertensive; "Deep breathing" OR "Breathing Exercises" OR "Paced Breathing"; Full Text Available; all Adults; Major Heading: Hypertension= 521 Results

Inclusion/Exclusion Criteria: English Language or Translated; Published Within Past 5 Years; Peer-Reviewed; PubMed Exclusion Terms Above

Results: 12

Combined CINAHL and PubMed Results (Duplicates Removed (4)) = 29 Results

Study selection

The selection of the studies occurred according to the exclusion and inclusion principles listed above. Empirical studies, as well as review articles were included.

Each paper that met the inclusion criteria was read in full; the subthemes were identified and categorized according to the "Study Appraisal & Synthesis Methods" section (see pg. ii).

Data collection process

The review author assessed studies for inclusion, extracted the data, and entered the data into Table 1. A librarian assisted with search terms, MeSH terms and navigating the databases.

Data items

To classify the levels of hierarchy in the second column of the table, the Johns-Hopkins Nursing EBP of classification was applied. Level I is defined as high quality, RCT. Level II is "good quality" and includes quasi-experimental studies or systematic reviews of a combination of RCT and quasi-experimental studies. Level III includes non-experimental studies and systematic

reviews of RCT, quasi-experimental studies, and non-experimental studies. Level IV includes opinions of respected authorities or committees. Level V includes literatures reviews and case reports.

Summary measures

Data were summarized based on decisions made by analyzing results that pertained to deep breathing exercises and their effects on blood pressures. The articles were then categorized according to their impressions on approval for implementation of the deep-breathing practices for lowering blood pressure (see objectives).

Synthesis of results

Each study was reviewed to determine if it fully supported the implementation of, supported the implementation after further studies, or did not support the implementation of slow-deep breathing as a non-pharmacological treatment for hypertension or the prevention of hypertension.

Risk of bias across studies

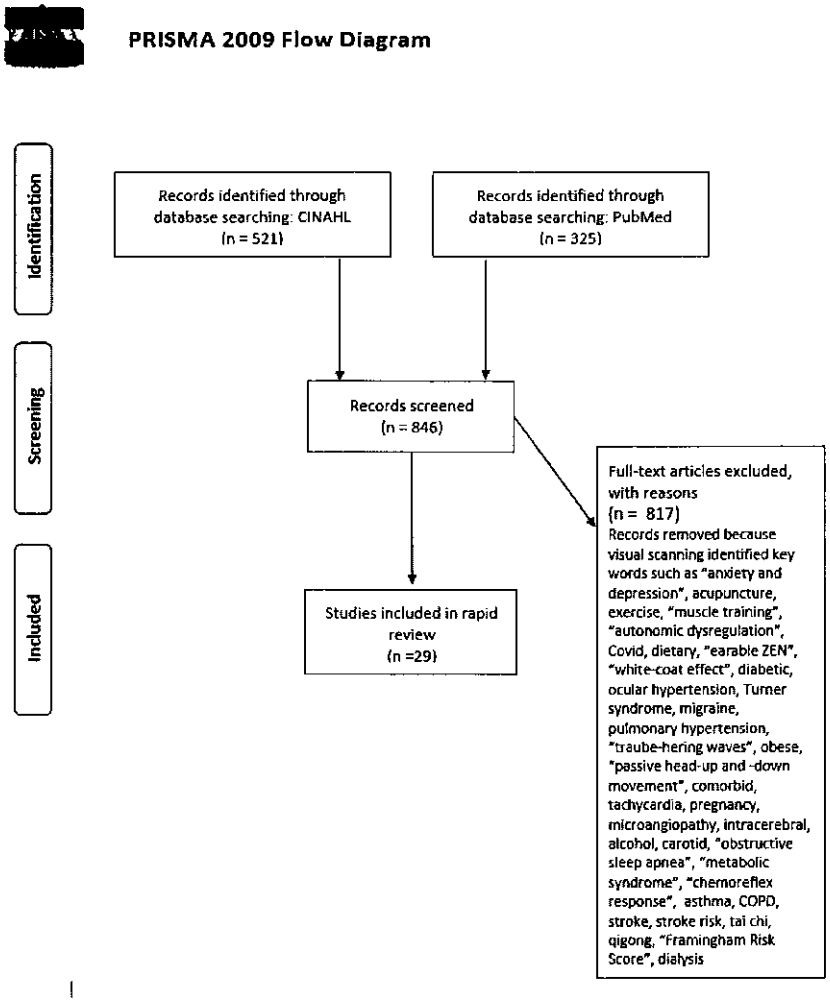
1. Publication bias – only studies with significant findings are often published
2. RCTs- highest quality level is often underrepresented
3. Quality of studies: See Table 1 for level of evidence
4. Population bias – studies focus on adults over age 50

Results

Diagram 1

Study Selection Flow Diagram

Study selection



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement.* PLoS Med 6(7): e1000097. doi: 10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org

Table 1

Summary of Reviewed Literature

Reference	Evidence Level/Study Design	Study Aim	Setup and Outcomes Assessed	Results	Authors' Conclusions
(Benjarat, Chulee et al. 2016) CINAHL	Level I/ Double Blind Randomized Controlled Trial	"Investigated whether slow breathing training, with and without an inspiratory load, could reduce the resting blood pressure of older well-managed ISH patients."	Prospective Randomized Control Trial "Thirty ISH patients (66 T 4 yr) were randomized into loaded breathing (six breaths per min, 18 cm H2O), unloaded breathing (six breaths per min, no load), or control (normal breathing) groups. After a 2-wk run-in, loaded and unloaded groups trained at home for 30 min every day for 8 wk. Morning home blood pressure and heart rate were measured daily throughout the	"Within-group analysis showed the loaded group to differ significantly from pretraining run-in from weeks 6 to 14 (P e 0.035) and for the unloaded group from weeks 4 to 10 with the maximum reduction occurring after the full 8 wk of training, amounting to 18 T 7 (95% confidence interval [CI] = j13 to j22) and 11 T 4 (95%CI = j9 to j13) mm Hg for the loaded and unloaded groups, respectively. Post hoc analysis showed significant	"We found [breathing training] to significantly reduce systolic and pulse pressure even in patients who were apparently well managed with conventional medication. The reductions were greatest when using loaded breathing, and the benefits after loaded breathing training were sustained for 6 wk after the end of training."

			study. At the end of training, all participants reverted to normal breathing, and blood pressure and heart rate were recorded for a further 8 wk.	differences between loaded and unloaded groups at weeks 7 (P = 0.049), 8 (P = 0.02), and 9–14 (P e 0.014)."	
(Brandani, Mizuno, et al., 2017) CINAHL & PubMed	Level I/ Systematic Review	"to evaluate the effect of pranayama (Yoga's breathing exercises) on BP and its applicability in the treatment of hypertension"	"Thirteen trials, assessing acute (eight studies) and chronic (five studies) BP response to pranayama were included"	"Significant BP reductions after pranayama were found in both acute (2-10 mmHg mean SBP reduction, N = 5 studies; 1 mmHg mean DBP reduction, N = 1 study) and chronic studies (4-21 mmHg mean SBP reduction, N = 3 studies; 4-7 mmHg mean DBP reduction, N = 2 studies)"	"Interventions with slow and alternate pranayamas appear to be effective to reduce blood pressure in normal and hypertensive patients. However, the evidence must be regarded as preliminary …Methodological improvements are required so that we can get reliable results and to earning potential for the inclusion of pranayamas as a complement to pharmacological treatment"
(Brenner, LeBlang et	Level V/ Literature Review	To determine if "mindfulness with paced breathing	"eligible and willing subjects would be assigned at	This article did not consist of actual trials, but was rather a hypothesis of	"The hypothesis that mindfulness with paced

al. 2020) CINAHL		decreases BP."	random to mindfulness with paced breathing or mindfulness without paced breathing. In this trial, the primary outcome would be BP reduction…" "An adequate test of the hypothesis that mindfulness with paced breathing reduces BP requires a sample size of about 400 to achieve 90% power"	the effects of mindfulness and paced breathing on decreased BP.	breathing will reduce BP is promising but unproven."
(Catela and Mercê 2019) CINAHL	Level I/ Randomized Controlled Trial	"To verify the effect of learned diaphragmatic breathing on cardiac autonomic function in elderly with Mild to Moderate Isolated Systolic Hypertension (MMS)."	"Vital signs were collected in 22 elderly (76.36 _ 7.93 years old, 13 women); 13 with optimal to Normal High Blood Pressure (ONH group) and 9 with MMS, in the supine position, during 6 min in each of two	"in B [normal pace breath], MMS group had significantly higher Diastolic Pressure (DP), but in D [slow paced learned breath] no significant difference was found between groups. Also, compared to B, in D MMS group significantly	"Results of this study support the hypothesis that an easily learned diaphragmatic breathing technique, inexpensive and non-intrusive, can help elderly with isolated systolic hypertension, to remediate its effects on vital signs."

			conditions: i) Baseline (B)- normal pace breath; ii) Diaphragmatic (D)- slow pace learned breath. Interval RR was collected through Polar V800, and gHRV software was used for Heart Rate Variability (HRV) analysis."	reduced Systolic Pressure (SP), DP and Pulse (difference between SP and DP)."	
(Jiménez-Rodríguez, Conesa-Garcerán et al. 2019) CINAHL	Level II/ Quasi-Experimental Study	"To evaluate whether the application of a relaxation therapy reduces the blood pressure in hypertensive patients and whether there is improvement in several parameters which can influence blood pressure such as anxiety, quality of life and sleep"	"A quasi-experimental study (measures before-after) was performed in 25 Primary Care patients with hypertension poorly controlled by pharmacological treatment. The intervention consisted of relaxation therapy composed of 3 techniques: passive relaxation of Schwartz-Haynes, diaphragmatic breathing and imaginary	"After intervention, a reduction in systolic blood pressure of 20 mmHg ($p < .001$) and of 8 mmHg ($p < .001$) in diastolic blood pressure was observed. Regarding other factors, sleep quality ($p < .001$), quality of life ($p < .001$) and state anxiety ($p = .004$) were significantly improved."	"such strategies should be evaluated more thoroughly to consider their inclusion in Primary Care"

			visualization. A total of 14 group sessions of 30 min each (2/week) were conducted."		
(Lokesh and Sudhan 2017) CINAHL	Level I/ Experimental Study	To determine if "progressive resisted exercise lowers the blood pressure."	"Experimental study design." "The 20 hypertensive subjects were selected and explained about the study… The parameters such as blood pressure, respiratory rate, pulse rate, spo2 level were measured before and after the test and noted.	"Macqueen's technique of progressive resisted exercise showed statistically significant improvement in resting blood pressure values at the end of 4th week compared to baseline values (Group I). Macqueen's technique of progressive resisted exercise with breathing control technique showed statistically improvement in resting blood pressure values at the end of 4th week compared to baseline values (Group II)."	"We can conclude that hypertension can be reduced by using Macqueen's progressive resisted exercise and breathing control training."
(Misra, Smith	Level I/ Randomized	"Our objective was to determine	"Eligible participants were	"Intervention participants were	"In this RCT, statistically significant

et al. 2019) CINAHL	Controlled Trial	whether 15 min yogic breathing exercises practiced 5 times a week can lower blood pressure in uncontrolled hypertensive patients"	randomly assigned to in-class instruction (n = 44), DVD/YouTube group (n = 57), or control (n = 32)."	significantly more likely to have ≥5 mm Hg decrease in systolic blood pressure (OR = 4.49, 95% CI: 1.18–17.0) compared to controls in the multivariable logistics model"	systolic blood pressure reduction was noted in the intervention groups. Yogic breathing exercises may provide an additional non-pharmacologic tool to treat uncontrolled blood pressure… They along with other researchers suggest that both sympathetic and parasympathetic reactivity associated with the slow-breathing aspect of the exercise may be the mechanism for blood pressure reduction."
(Shetty, Reddy B et al. 2017) CINAHL & PubMed	Level I/ Randomized Controlled Trial	"The study aimed to measure the effects of Sheetali and Sheetkari pranayamas on BP, the autonomic nervous system, and respiratory	"The study was a randomized controlled clinical trial with pre- and postintervention evaluations following the 30-day study."	"Compared to control, the intervention group showed a significant mean decrease in (1) systolic blood pressure (SBP)—16.2 mm Hg ($P \leq$	"Sheetali and Sheetkari pranayamas appear effective for lowering SBP in individuals with HTN…Given the low risk and apparent

		functions among hypertensive participants."	"Participants were randomly assigned either to an intervention group (n = 30) or wait-list control groups (n = 30). The intervention included 2 types of pranayama breath practices (ie, Sheetali and Sheetkari) each practiced for 10 min/d…BP and autonomic and respiratory functions were measured at baseline and postinterventio n."	.001), (2) respiratory rate—3.4 rpm ($P < .001$), and (3) heart rate—6.7 bpm ($P \leq .01$)."	clinically meaningful effects of a >5 mm Hg reduction in SBP, additional clinical research on pranayama, an established limb of yoga, is warranted."
(Spies shoefe r, Becke r et al. 2019) CINA HL	Level I/ Randomi zed Controll ed Trial	"To investigate the effects of voluntary hyperventilati on and simulated PB [periodic breathing] on hemodynamic s and SVB [sympatho-vagal balance] in healthy subjects, in patients with	"Study participants (n = 20 per group) underwent non-invasive recording of diastolic blood pressure, heart rate variability (HRV), baroreceptor-reflex sensitivity (BRS), total peripheral resistance	"In PAH patients, voluntary hyperventilatio n led to a 15% decrease in the high-frequency component of HRV ($p <$ 0.05) and a 5% increase in CI ($p < 0.05$)."	"Simulated PB [periodic breathing] had positive effects on SVB [sympatho-vagal balance] in healthy volunteers but neutral effects on SVB and hemodynamic s in patients with HF or PAH"

		systolic HF and reduced or mid-range ejection fraction (HFrEF and HFmrEF) and in patients with PAH [pulmonary arterial hypertension"	index (TPRI) and cardiac index (CI). All measurements were performed at baseline, during voluntary hyperventilation and during simulated PB with different length of the hyperventilation phase."		
(Thanalakshmi, Maheshkumar et al. 2020) CINAHL & PubMed	Level I/ Randomized Controlled Trial	"The primary outcome of the study is to determine the effect of *Sheetali* pranayama (Cooling)) on cardiac autonomic functions using heart rate variability (HRV). The secondary outcome is to find impact of *Sheetali* pranayama on resting blood pressure variables."	"The current study was conducted on 100 patients with HTN, randomly allocated to HTN with pranayama (Intervention group,n ¼ 50) and HTN without pranayama (control group,n ¼ 50) group. The intervention group practiced *Sheetali* pranayama for a period of 3 months. Blood pressure and HRV was assessed before and after the intervention."	"Intervention group showed a significant ($P < 0.05$) reduction in blood pressure variables when compared to the control group."	"*Sheetali* pranayama significantly reduces blood pressure in patients with HTN and improved heart rate variability. *Sheetali* pranayama could thus be practiced in addition to regular medications for the efficacious management of HTN."

(Ubolsakka-Jones, Tongdee et al. 2019) CINAHL	Level I/ Randomized Controlled Trial	To determine "whether [slow loaded breathing training] also reduces their exaggerated BP responses to exercise."	"The study was a randomized controlled trial with block allocation stratified by sex. Twenty ISH patients (68 ± 5 yrs, 11 males) were randomized with one group undertaking 8-weeks training with slow loaded breathing (SLB: 25% maximum inspiratory pressure, 6 breaths per minute, 60 breaths every day) or deep breathing control (CON), with 8 weeks follow-up. Outcome measures were home BP and heart rate (HR) with laboratory measures of BP and HR responses to static handgrip and dynamic arm cranking exercise."	"Home systolic BP fell by 22 mmHg (20–23; mean, 95% CI), diastolic BP by 9 mmHg (7–11), and HR by 12 bpm (9–15; all $p < .001$) as a result of SLB training.	"The results reported here show that 8 weeks of SLB training not only reduced resting BP and HR but also the responses to both static and dynamic exercise. Moreover, significant reductions in resting sBP and PP remained 8 weeks after the end of training, and the attenuated response to exercise was still evident 4 weeks after training…If SLB were to be widely used in conjunction with conventional drug therapy, it could result in considerable savings in the cost of health care for an aging population."

Reference		Study Aim	Setup and Outcomes Assessed	Results	Authors' Conclusions
(Cernes & Zimlichman, 2017) PubMed	Level III / Systematic Review of a combination of RCTs and quasi-experimental, or quasi-experimental studies only	Review the literature	N/A	N/A	Device-guided paced breathing (DGB) may be recommended for those who cannot obtain full control of their hypertension with medical therapy alone or cannot tolerate potential side effects of pharmacologic treatment.
(Hamasaki, 2020) PubMed	Level II/ Systematic Review of RCTs and Systematic Reviews	"the effects of DB on human health need to be further investigated."	"The author conducted a PubMed search regarding the current evidence of the effect of DB on health."		"Based on this narrative review, the exact usefulness of DB in clinical practice is unclear due to the poor quality of studies. However, it may be a feasible and practical treatment method for various disorders. "
(Ublosakka-Jones, Tongdee, et	Level I/ Randomized controlled trial	"Slow loaded breathing training reduces resting blood	"Thirty-two people (67 ± 5 years, 16 male) with controlled	"Home based measurement of resting systolic BP decreased by	"Slow inspiratory muscle training is not only effective

al., 2018) PubMed	with block allocation stratified by sex	pressure and the question is whether this can also improve lung function."	isolated systolic hypertension undertook an eight weeks randomised controlled training trial with an inspiratory load of 25% maximum inspiratory pressure (MIP) at 6 breaths per minute (slow loaded breathing; SLB) or deep breathing control (CON). "	20 mm Hg (15 to 25) (Mean and 95%CI) for SLB and by 5 mm Hg (1 to 7) for CON."	in reducing resting BP, even in older people with well controlled isolated systolic hypertension but also increases inspiratory muscle strength, lung capacity and arm exercise duration."
(Gholamreza ei, Van Diest, et al., 2021) PubMed	Level I/ Randomized Controlled Trial	To assess the Psychophysiological responses to various slow, deep breathing techniques	"compared four deep breathing techniques and examined outcomes in blood pressure variability, respiratory sinus arrhythmia, baroreflex function, and emotional state… Healthy adult volunteers performed pursed-lips breathing, left and right unilateral nostril	" blood pressure variability was higher during loaded breathing versus other conditions and higher during pursed-lips breathing versus left and right unilateral nostril breathing… loaded breathing was associated with enhanced cardiovascular effects"	"These findings can be informative in applying deep breathing techniques as self-management interventions for health conditions, in which baroreceptors stimulation and autonomic and emotional modulations can be beneficial, such as pain and hypertension."

			breathing, and deep breathing with an inspiratory threshold load (loaded breathing)"		
(Chaddha, Modaff, et al., 2019) PubMed	Level I/ Systematic review and meta-analysis	"assesses the impact of device-guided and non-device-guided (pranayama) slow breathing on blood pressure reduction in these patient populations."	"We searched PubMed, EMBASE, CINAHL, Cochrane CENTRAL, Cochrane Database of Systematic Reviews, Web of Science, BIOSIS (Biological Abstracts) Citation Index and Alt HealthWatch for studies meeting these inclusion criteria: randomized controlled trial or first phase of a randomized cross-over study; subjects with hypertension, prehypertension or on antihypertensive medication; intervention consisting of slow breathing at ≤10 breaths/minute	"Overall, slow breathing decreased SBP by -5.62 mmHg [-7.86, -3.38] and DBP by -2.97 mmHg [-4.28, -1.66]."	"Slow breathing showed a modest reduction in blood pressure. It may be a reasonable first treatment for low-risk hypertensive and prehypertensive patients who are reluctant to start medication."

			for ≥5 min on ≥3 days/week; total intervention duration of ≥4 weeks; follow-up for ≥4 weeks; and a control group."		
(Adler, Coovadia, et al., 2019) PubMed	Level I/ Randomized Controlled Trial	" the extent to which blood pressure (BP) responses to SLOWB differ between men and women are not well-established. Therefore, we tested the hypothesis that an acute bout of SLOWB would induce larger decreases in BP in males than in females, given that males typically have higher resting BP"	"We tested normotensive females (n = 10, age: 22 ± 2 y, body mass index: 22 ± 2 kg/m^2) and males (n = 12, age: 23 ± 3 y, body mass index: 26 ± 4 kg/m^2). Subjects were tested at baseline and during the last 5 min of a 15-min RESPeRATE-guided SLOWB session"	"Overall, SLOWB reduced systolic BP by 3.2 ± 0.8 mmHg (main effect, P < 0.01)."	"We provide support for the effectiveness of device-guided slow breathing for blood pressure reduction in young normotensive women and men…slow breathing appears to be effective in young healthy normotensive individuals of both sexes and may be an ideal preventative therapy against future hypertension."
(Gholamreza ei, Van Diest, et al., 2019)	Level I/ Randomized Controlled Trial	"We investigated whether adding inspiratory threshold load can enhance the cardiovascula	"Healthy volunteers (N = 29) performed controlled breathing at 0.1 Hz (6 breaths/minute) without load	"The amplitude of the systolic blood pressure variation during respiratory cycles increased with	"The potential benefit of long-term practice of controlled breathing at 0.1 Hz with inspiratory threshold

PubMed		r responses to controlled breathing at the frequency of 0.1 Hz, a common form of slow, deep breathing."	and with inspiratory threshold loads of 5 cmH_2O and 10 cmH_2O. Respiratory airflow, heart rate, and blood pressure were continuously recorded."	increasing loads"	loads on baroreflex function and cardiac vagal control needs to be investigated, particularly in pain and hypertension patients"
(Rodrigues, Gurgel, et al., 2018) PubMed	Level I/ Randomized Controlled Trial	"To investigate the influence of breathing patterns and blood pressure behavior postural control in older adults."	"A total of 20 older adults carried out spontaneous, controlled (15 cycles/min) and deep (6 cycles/min) breathing trials, in random order"	"there were also significant differences in systolic blood pressure during spontaneous breathing between the baseline measures (sitting position 123 ± 11 mmHg) and the first minute of active standing (117 ± 13 mmHg; d = 0.24; P < 0.05)."	''
(Ghati, Killa, et al., 2020) PubMed	Level I/ Randomized Controlled Trial	"The present study was designed to evaluate the immediate effect of BHB (a simple yogic practice) exercise on blood pressure parameters and heart rate variability	"a randomized control trial including 70 patients with essential hypertension, randomly allocated to perform either BHB exercise (n=35) or placebo slow breathing exercise (n = 35) for 5-	" There was no significant decrease in systolic [effect size (95% CI): 2.22 (-13.20, 17.64); p 0.77], diastolic [4.54 (-17.40, 26.48); p 0.68] and mean blood pressures [1.37 (-8.78, 11.52); p 0.78] after BHB exercise	"This is the first randomized controlled trial to show that though a single short session of BHB exercise in hypertensive patients does not significantly reduce BP, it

		(HRV) in patients with essential hypertension. "	minutes duration. Blood pressure and HRV were measured before, during, and after the practice."	in comparison to the control group in our study."	significantly augments the parasympathetic tone as indicated by a significant improvement in HRV parameters"
(Fonkoue, Marvar, et al., 2018) PubMed	Level I/ Randomized Controlled Trial	"We hypothesized that DGB acutely lowers BP, heart rate (HR), and improves BRS in PTSD"	"In 23 prehypertensive veterans with PTSD, we measured continuous BP, ECG, and muscle sympathetic nerve activity (MSNA) at rest and during 15 min of DGB at 5 breaths/min (n = 13) or identical sham device breathing at normal rates of 14 breaths/min (sham; n = 10)."	"There was a significant reduction in systolic BP (by -9 ± 2 mmHg, $P < 0.001$), diastolic BP (by -3 ± 1 mmHg, P = 0.019), mean arterial pressure (by -4 ± 1 mmHg, P = 0.002), and MSNA burst frequency (by -7.8 ± 2.1 bursts/min, P = 0.004) with DGB but no significant change in HR ($P > 0.05$)."	"DGB acutely lowers BP and MSNA and improves sympathetic but not cardiovagal BRS in prehypertensive veterans with PTSD"
(Mahtani, Beinortas, et al., 2016) PubMed	Level V/ Summary Evidence Review	"summarise the evidence base on efficacy [of the Respirate]"	Summary Evidence Review	"although some clinical trials exist that demonstrate a BP-lowering effect, others do not."	"There is currently insufficient evidence from pooled data to recommend the routine use of device-guided breathing in hypertensive patients."

(Lachowska, Bellwon, et al., 2019) PubMed	Level I/ Randomized Controlled Trial	"We examined the acute and long-term impact of device-guided breathing on hemodynamics and prognostic parameters in HF patients with reduced ejection fraction (HFrEF)."	"Twenty-one patients with HFrEF (23.9 ± 5.8%, SD ± mean) on optimal medical therapy underwent blood pressure (BP), heart rate (HR), HR variability, 6-min walk test (6MWT), cardiopulmonary exercise testing (CPET), and echocardiography measurements before and 3 months after SLOWB home training (30 min daily). After 3 months, all patients were assigned to continue SLOWB (Group 1) or no-SLOWB (Group 2). All tests were repeated after 6 months."	"Acute SLOWB (18 ± 5 vs 8 ± 2 breaths/min, P < 0.001) had no influence on BP and HR but improved saturation (97 ± 2 vs 98 ± 2%, P = 0.01). Long-term SLOWB reduced office systolic BP (P < 0.001) but not central or ambulatory systolic BP."	"SLOWB training improves cardiorespiratory capacity and appears to slow the progression of HFrEF. Further long-term outcome studies are required to confirm the benefits of paced breathing in HFrEF."
(Krüerke, Simões-Wüst, et al., 2018)	Level I/ Randomized Controlled Trial	"This prospective, exploratory, pre-post study was performed to investigate	"Patients received three ATS treatments, alternating with three sham	"The mean systolic BP did not change significantly during this study."	"The results indicate that ATS has the potential to improve cardiovascular parameters

CINAHL & PubMed		ATS effects on baroreflex sensitivity (BRS), heart rate (HR), HRV by standard deviation of beat to beat intervals (SDNN), blood pressure (BP), and mood in hypertensive patients."	interventions (control). During the sessions, BP and electrocardiography were continuously recorded. BRS and SDNN were analyzed from those measurements. Changes in mood score were assessed by a questionnaire. All data were compared before and after intervention (ATS and control)."		which play an important role in BP regulation capability."
(Yau & Loke, 2021) PubMed	Level V/ Literature Review	"examine the effects of diaphragmatic breathing on physiological and psychological measures in prehypertensive or hypertensive adults and to (2) determine the appropriate length, frequency, and duration of an effective diaphragmatic	"Relevant studies were searched using electronic databases, and 13 studies that met the inclusion criteria were included."	"voluntary diaphragmatic deep breathing resulted in decreased of systolic and diastolic blood pressures, reduced heart rate, a relaxing effect, and reduced anxiety in hypertensive or prehypertensive individuals."	"It is concluded that voluntary diaphragmatic breathing at <10 or 6 breaths per minute for 10 min twice a day for 4 weeks was effective in producing positive outcomes. The results of this review provide directions for related interventions

		breathing exercise in the management of prehypertension and hypertension."			and future research"
(Sangthong, Ubolsakka-Jones, et al., 2016) PubMed	Level I/ Randomized Controlled Trial	"investigated whether slow breathing training, with and without an inspiratory load, could reduce the resting blood pressure of older well-managed ISH patients."	"Thirty ISH patients (66 ± 4 yr) were randomized into loaded breathing (six breaths per min, 18 cm H2O), unloaded breathing (six breaths per min, no load), or control (normal breathing) groups. After a 2-wk run-in, loaded and unloaded groups trained at home for 30 min every day for 8 wk. Morning home blood pressure and heart rate were measured daily throughout the study. At the end of training, all participants reverted to normal breathing, and	"systolic blood pressure was reduced by 18 ± 7 and 11 ± 4 mm Hg for loaded and unloaded groups, respectively ($P < 0.001$), the reduction being significantly larger for the loaded group ($P < 0.05$) after 8-wk training. There were no changes in the control group. After the end of training, systolic blood pressure remained below pretraining levels for a further 6 wk for the loaded group but for only 2 wk with the unloaded group. There was a small nonsignificant reduction in diastolic blood	"Slow breathing training, especially with an inspiratory load, is very effective in reducing resting systolic and pulse pressures and could be a valuable adjunct in the management of ISH."

			blood pressure and heart rate were recorded for a further 8 wk."	pressure with training, as there was for heart rate."	
(Chauhan, Semwal, et al., 2017) PubMed	Level I/ Randomized Controlled Trial	"to evaluate the effect of 1-month yoga practice on body mass index (BMI), and blood pressure (BP)."	" determine the effect of yoga practice on 64 participants (age 53.6 ± 13.1 years) (experimental group) whereas the results were compared with 26 healthy volunteers (control group). We examined the effects of yoga on physiological parameters in a 1-month pilot study. Most of the participants were learner and practiced yoga for 1 h daily in the morning for 1 month. BMI and BP (systolic and diastolic) were studied before and after 1 month of yoga practice."	"Yoga practice causes decreased BMI (26.4 ± 2.5-25.22 ± 2.4), systolic BP (136.9 ± 22.18 mmHg to 133 ± 21.38 mmHg), and diastolic BP (84.7 ± 6.5 mmHg to 82.34 ± 7.6 mmHg). On the other hand, no significant changes were observed in BMI and BP of control group."	"This study concludes that yoga practice has potential to control BMI and BP without taking any medication."
(de Barros, da	Level I/ Randomized	"to evaluate the long-term use of DGB	"Hypertensive patients were randomized to	"There was no change in office BP	"Long-term DGB did not reduce BP,

Silva, et al., 2017) PubMed	open-label clinical trial	in BP and SNA."	listen music (Control Group-CG) or DGB (aim to reduce respiratory rate to less than 10 breaths/minute during 15 minutes/day for 8 weeks). Before and after intervention ambulatory blood pressure monitoring (ABPM), catecholamines and muscle sympathetic nerve activity (MSNA) by microneurography were performed."	before and after intervention in both groups. There was a reduction in systolic and diastolic BP in the awake period by ABPM only in the CG (131 ± 10/92 ± 9 vs 128 ± 10/88 ± 8mmHg, $p < 0.05$). In relation to SNA, no difference in catecholamines was observed."	catecholamines levels or MSNA in hypertensive patients."
(Posser, Calleg aro, et al., 2016) PubMed	Level I/ Double-Blind Randomized Controlled Trial	"test the efficacy of inspiratory muscle training in reducing blood pressure in adults with essential hypertension"	" randomized, double-blind clinical trial… Intervention consists of inspiratory muscle training loaded with 40 % of maximum inspiratory pressure, readjusted weekly. Control sham intervention consists of unloaded	Unresolved	

			exercises. Systolic and diastolic blood pressures are co-primary endpoint measures assessed with 24 h ambulatory blood pressure monitoring."		

Study characteristics

See Table 1

Results of individual studies

See Table 1

Additional analysis

No additional analyses completed

Discussion

Summary of evidence

- Slow-loaded breathing decreases blood pressure more than slow breathing alone.
- 11 studies supported the implementation of slow-deep breathing or a similar variant as an evidence-based practice to reduce blood pressures
- 12 studies supported the implementation contingent on additional research
- Two studies did not support the implementation, but still seemed hopeful with continued research

- Two studies did not support the implementation of a slow-deep breathing protocol or a similar variant
- One study revealed no change in BP with an acute slow-deep breathing variant, but a decrease in BP long term
- One study was unresolved

Limitations

Limitations to this study include time constraints, some low-quality evidence (level V), and the use of only two databases.

Conclusions

Additional studies must be conducted to add to the evidence demonstrating that slow-deep breathing alone reduces blood pressures. In addition, the effects of slow-deep breathing on blood pressure should be studied acutely (one week to one month, once a day) and long-term (six weeks, once a day). Ideally, the studies would then assess for the slow-deep breathing's effects on blood pressure for one month follow-up after the slow-deep breathing practice has concluded. In bedside nursing, this would mean providing education to the patient regarding the effectiveness of deep breathing, the consequences of prolonged hypertension, and the benefits of a deep breathing protocol over antihypertensive medications. In public health, this deep breathing protocol could also prove beneficial where the protocol may be implemented in a community health education class. This would include education on the same topics discussed for bedside nursing and demonstration of the proper breathing technique so citizens can confidently perform the protocol at home. The rise of hypertension in the United States necessitates the widespread use of an effective and simple slow-deep breathing protocol.

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References

Adler, T. E., Coovadia, Y., Cirone, D., Khemakhem, M. L., & Usselman, C. W. (2019). Device-guided slow breathing reduces blood pressure and sympathetic activity in young normotensive individuals of both sexes. Journal of Applied Physiology, 127(4), 1042-1049. doi:10.1152/japplphysiol.00442.2019

Baker-Goering, M. M., Roy, K., & Howard, D. H. (2019). Relationship Between Adherence to Antihypertensive Medication Regimen and Out-of-Pocket Costs Among People Aged 35 to 64 With Employer-Sponsored Health Insurance. *Preventing Chronic Disease, 16.* doi:10.5888/pcd16.180381

Brandani, J. Z., Mizuno, J., Ciolac, E. G., & Monteiro, H. L. (2017). The hypotensive effect of Yoga's BREATHING exercises: A systematic review. Complementary Therapies in Clinical Practice, 28, 38-46. doi:10.1016/j.ctcp.2017.05.002

Brenner, J., LeBlang, S., Lizotte-Waniewski, M., Schmidt, B., Espinosa, P. S., DeMets, D. L., & Hennekens, C. H. (2020). Mindfulness with paced breathing reduces blood pressure. Medical Hypotheses, 142, 109780. doi:10.1016/j.mehy.2020.109780

Catela, D., & Mercê, C. (2019). P3 diaphragmatic breathing technique an example of motor literacy for health in elderly with isolated systolic hypertension. European Journal of Public Health, 29(Supplement_2). doi:10.1093/eurpub/ckz096.007

Cernes, R., & Zimlichman, R. (2017). Role of paced breathing for treatment of hypertension. Current Hypertension Reports, 19(6). doi:10.1007/s11906-017-0742-1

Chaddha, A., Modaff, D., Hooper-Lane, C., & Feldstein, D. A. (2019). Device and non-device-guided slow breathing to reduce blood pressure: A systematic review and meta-analysis. Complementary Therapies in Medicine, 45, 179-184. doi:10.1016/j.ctim.2019.03.005

Chauhan, A., Semwal, D. K., Mishra, S. P., & Semwal, R. B. (2017). Yoga Practice Improves the Body Mass Index and Blood Pressure: A Randomized Controlled Trial. International journal of yoga, 10(2), 103–106. https://doi.org/10.4103/ijoy.IJOY_46_16

Coutinho Myrrha, M. A., Vieira, D. S., Moraes, K. S., Lage, S. M., Parreira, V. F., & Britto, R. R. (2013). Chest wall volumes during inspiratory loaded breathing in copd patients. *Respiratory Physiology & Neurobiology, 188*(1), 15-20. doi:10.1016/j.resp.2013.04.017

de Barros, S., da Silva, G. V., de Gusmão, J. L., de Araújo, T. G., de Souza, D. R., Cardoso, C. G., Jr, Oneda, B., & Mion, D., Jr (2017). Effects of long term device-guided slow breathing on sympathetic nervous activity in hypertensive patients: a randomized open-label clinical trial. Blood pressure, 26(6), 359–365. https://doi.org/10.1080/08037051.2017.1357109

Fonkoue, I. T., Marvar, P. J., Norrholm, S. D., Kankam, M. L., Li, Y., DaCosta, D., . . . Park, J. (2018). Acute effects of device-guided slow breathing on sympathetic nerve activity and baroreflex sensitivity in posttraumatic stress disorder. American Journal of Physiology-Heart and Circulatory Physiology, 315(1). doi:10.1152/ajpheart.00098.2018

Ghati, N., Killa, A. K., Sharma, G., Karunakaran, B., Agarwal, A., Mohanty, S., . . . Pandey, R. (2020). A randomized trial of the immediate effect of bee-humming breathing exercise on

blood pressure and heart rate variability in patients with essential hypertension. EXPLORE. doi:10.1016/j.explore.2020.03.009

Gholamrezaei, A., Van Diest, I., Aziz, Q., Vlaeyen, J. W., & Van Oudenhove, L. (2019). Influence of inspiratory threshold load on cardiovascular responses to controlled breathing at 0.1 Hz. Psychophysiology, 56(11). doi:10.1111/psyp.13447

Gholamrezaei, A., Van Diest, I., Aziz, Q., Vlaeyen, J. W., & Van Oudenhove, L. (2020). Psychophysiological responses to various slow, deep breathing techniques. Psychophysiology, 58(2). doi:10.1111/psyp.13712

Hamasaki, H. (2020). Effects of diaphragmatic breathing on health: A narrative review. Medicines, 7(10), 65. doi:10.3390/medicines7100065

Jiménez-Rodríguez, D., Conesa-Garcerán, M., & Belmonte-García, T. (2019). Evaluation of the effect of relaxation therapy in patients with arterial hypertension. Enfermería Clínica (English Edition), 29(3), 178-185. doi:10.1016/j.enfcle.2018.10.002

Johns Hopkins Medicine, based in Baltimore, Maryland. (2021, March 18). Retrieved March 25, 2021, from https://www.hopkinsmedicine.org/

Krüerke, D., Simões-Wüst, A. P., Kaufmann, C., Frank, M., Faldey, A., Heusser, P., & von Bonin, D. (2018). Can Speech-Guided Breathing Influence Cardiovascular Regulation and Mood Perception in Hypertensive Patients?. Journal of alternative and complementary medicine (New York, N.Y.), 24(3), 254–261. https://doi.org/10.1089/acm.2017.0158

Lachowska, K., Bellwon, J., Narkiewicz, K., Gruchała, M., & Hering, D. (2018). Long-term effects of device-guided slow breathing in stable heart failure patients with reduced ejection fraction. Clinical Research in Cardiology, 108(1), 48-60. doi:10.1007/s00392-018-1310-7

Lokesh, R., & Sudhan, S. G. (2017). A comparitive study on the effect of macqueen's progressive resisted exercise and breathing control training on hypertensives. Indian Journal of Physiotherapy and Occupational Therapy - An International Journal, 11(3), 132. doi:10.5958/0973-5674.2017.00089.2

Mahtani, K. R., Beinortas, T., Bauza, K., & Nunan, D. (2016). Device-guided breathing for hypertension: A summary evidence review. Current Hypertension Reports, 18(4). doi:10.1007/s11906-016-0631-z

Misra, S., Smith, J., Wareg, N., Hodges, K., Gandhi, M., & McElroy, J. A. (2019). Take a deep breath: A randomized control trial of Pranayama breathing on uncontrolled hypertension. Advances in Integrative Medicine, 6(2), 66-72. doi:10.1016/j.aimed.2018.08.002

Posser, S. R., Callegaro, C. C., Beltrami-Moreira, M., & Moreira, L. B. (2016). Effect of inspiratory muscle training with load compared with sham training on blood pressure in individuals with hypertension: study protocol of a double-blind randomized clinical trial. Trials, 17, 382. https://doi.org/10.1186/s13063-016-1514-y

Prevalence of Self-Reported Hypertension and Antihypertensive Medication Use Among Adults Aged ≥18 Years - United States, 2011–2015. (2018, February 22). Retrieved January 05, 2021, from https://www.cdc.gov/mmwr/volumes/67/wr/mm6707a4.htm

Publication manual of the American Psychological Association. (2010). Washington, DC: American Psychological Association.

Rodrigues, G. D., Gurgel, J. L., Gonçalves, T. R., Porto, F., & Soares, P. P. (2018). Influence of breathing patterns and orthostatic stress on postural control in older adults. Geriatrics & Gerontology International, 18(5), 692-697. doi:10.1111/ggi.13231

Sangthong, B., Ubolsakka-Jones, C., Pachirat, O., & Jones, D. A. (2016). Breathing Training for Older Patients with Controlled Isolated Systolic Hypertension. Medicine and science in sports and exercise, 48(9), 1641–1647. https://doi.org/10.1249/MSS.0000000000000967

Sengupta P. (2012). Health Impacts of Yoga and Pranayama: A State-of-the-Art Review. International journal of preventive medicine, 3(7), 444–458.

Shetty, P., Reddy B, K. K., Lakshmeesha, D. R., Shetty, S. P., Kumar G, S., & Bradley, R. (2017). Effects of Sheetali and Sheetkari Pranayamas on Blood Pressure and Autonomic Function in Hypertensive Patients. Integrative medicine (Encinitas, Calif.), 16(5), 32–37.

Spiesshoefer, J., Becker, S., Tuleta, I., Mohr, M., Diller, G., Emdin, M., . . . Giannoni, A. (2019). Impact of simulated hyperventilation and periodic breathing on sympatho-vagal balance and hemodynamics in patients with and without heart failure. Respiration, 98(6), 482-494. doi:10.1159/000502155

Thanalakshmi, J., Maheshkumar, K., Kannan, R., Sundareswaran, L., Venugopal, V., & Poonguzhali, S. (2020). Effect of Sheetali PRANAYAMA on cardiac autonomic function among patients with PRIMARY Hypertension - a randomized controlled trial. Complementary Therapies in Clinical Practice, 39, 101138. doi:10.1016/j.ctcp.2020.101138

Ublosakka-Jones, C., Tongdee, P., Pachirat, O., & Jones, D. A. (2018). Slow loaded breathing training improves blood pressure, lung capacity and arm exercise endurance for older people with treated and stable isolated systolic hypertension. Experimental Gerontology, 108, 48-53. doi:10.1016/j.exger.2018.03.023

Vaghela, N., Mishra, D., Mehta, J. N., Punjabi, H., Patel, H., & Sanchala, I. (2019). Awareness and practice of aerobic exercise and yoga among hypertensive patients in Anand city. Journal of education and health promotion, 8, 28. https://doi.org/10.4103/jehp.jehp_146_18

Yau, K. K., & Loke, A. Y. (2021). Effects of diaphragmatic deep breathing exercises on prehypertensive or hypertensive adults: A literature review. Complementary therapies in clinical practice, 43, 101315. Advance online publication. https://doi.org/10.1016/j.ctcp.2021.101315