PRINCIPLES AND PRACTICE OF CLINICAL RESEARCH
A Global Journal of Clinical Research

The Efficacy of Deep Breathing Techniques in Patients with Elevated Blood Pressure and Hypertension: A Review of the Literature

Kelsie Lizbeth Pereyra-Bencosme[1], Diana Arango[2], Flavio Lichtenstein[3], Gabriela Alexandra Mateo[6,8], Alonso S Gormaz-Bravo[5], Ángel Jael Acosta[6], Bruno Antonio de Oliveira[7], Temidayo Olasinbo Avwioro[12], Adriano Fernandes Teixeira[4], Gerardo Y. Guinto-Nishimura[9], Laura Marie Bourget[6], Marta Figueral[10], Rodrigo Uribe-Pacheco[9*]

[1]Pontificia Universidad Católica Madre y Maestra, Santiago de los Caballeros, Dominican Republic; [2]IPS Sura Virtual, Medellin, Colombia; [3]Instituto Butantan / CENTD - Bioinformatics, Sao Paulo, SP, Brazil; [4]Federal University of Bahia, Salvador, Brazil; [5]Universidad del Desarrollo, Concepción, Chile; [6]Instituto Tecnológico de Santo Domingo, Santo Domingo, República Dominicana; [7]Instituto Butantan, Sao Paulo, SP, Brazil; [8]Boston Medical Center, Boston MA, USA; [9]Neurosurgery Department, Instituto Nacional de Neurología y Neurocirugía Manuel Velasco Suárez, Mexico City, México; [10]Universidade da Beira Interior, Portugal; [12]Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria.

Abstract

Introduction: *Increased blood pressure (BP) is among the top modifiable causes of cardiovascular disease risk. Non-pharmacological interventions in the prevention and management of elevated BP and hypertension have increased in popularity in recent years. Deep breathing techniques (DBT) are mindfulness stress reduction strategies that target the autonomous nervous system, increase vagal tone, and reduce BP levels. Inconsistent evidence exists in the efficacy of DB techniques in BP control. This review of the literature aims to assess the overall BP lowering efficacy of DBT in hypertension, compare the efficacy of device-guided versus non-device-guided DBT, and assess the safety and adherence rate of DBT, through systematic search and review of randomized controlled trials.*

Methods: *We searched Randomized clinical trials (RCT) in PubMed and Cochrane databases. The search terms were divided into three-term groups: a) hypertension, b) deep breathing techniques, and c) trials. Then, the list of articles was divided into five groups, each with two to three reviewers, to verify every study met the inclusion and exclusion criteria by reading the title and the abstract. Whenever necessary, we downloaded articles to verify adherence by reading the methods, results, and discussions. Studies having two or more votes were selected. Next, all selected articles were downloaded and read to analyze findings and effect sizes and to confirm a correct methodology and statistical analysis.*

Results: *We selected 4 of 119 articles. There is a conflict in the literature; one study affirms no overall difference between DBT and control, two studies affirm that there are statistically significant differences, and one study reports no difference in office BP but statistical difference in "awake, at home" monitoring in the control group. Thus large-scale, high-quality clinical trials are needed to critically assess the effectiveness of long-term DBT in the management of HTN.*

Introduction

Hypertension (HTN), defined as an increase in systolic blood pressure (SBP), diastolic blood pressure (DBP), or both, has been associated with an increased risk of cardiovascular disease (CVD) (Al-Makki et, 2021; Whelton et al., 2018). CVD is the leading cause of death and disability and is predicted to sustain this rank by 2040 (Al-Makki et al., 2021; Forouzanfar et al., 2016; Foreman et al., 2018). In August 2021, the World Health Organization estimated the prevalence of HTN is 1.28 billion adults aged 30-79, with less than a quarter having their BP under control (WHO, 2021). Elevated blood pressure, previously referred to as pre-hypertension, is categorized as SBP 120-129 mm Hg and DBP < 80 mm Hg, while stage I hyper-

*Corresponding author: rodrigouribe@neurocirugia-innn.com
Received: November 30, 2022 **Accepted:** December 2, 2022
Published: July 10, 2023
Editor: Felipe Fregni **Reviewers:** Vinicius Quintao, Luciana Garlisi, Santiago Callegari, Amaro Medina
Keywords: deep breathing technique, elevated blood pressure, hypertension, adults, randomized clinical trials
DOI: http://dx.doi.org/10.21801/ppcrj.2023.91.5

tension corresponds to SBP 130-139 mm Hg or DBP 80-89 mm Hg (Whelton et al., 2018). Even these mild to moderate elevations in BP significantly increase the CVD risk burden (Huang et al., 2015).

Prevention and treatment of elevated BP and HTN are heavily targeted to reduce their harmful health-related consequences. Non-pharmacological strategies alone are the mainstay for preventing HTN, but they are also combined with pharmacological therapies to treat all stages of the disease. Considering the challenge of adherence to antihypertensive medication, non-pharmacologic strategies have been of increasing interest among the medical and patient population (Mourya et al., 2009). Non-pharmacological strategies include weight loss, increased physical activity, implementation of heart-healthy diets, reduction of sodium consumption, incorporation of potassium supplementation into the diet (unless medically contraindicated), reduction of alcohol intake, and management of stress (Whelton et al., 2018; Fu et al., 2020).

The autonomic nervous system, specifically sympathetic overactivity, encompasses a branch of hypertension pathophysiology. Stress has been implicated in sympathetic overstimulation by its role in decreasing baroreflex sensitivity (Fu et al., 2020; Hamasaki, 2020; Valensi, 2021). Mindfulness meditation techniques are highly available, cost-effective, and safe interventions for stress reduction. Deep breathing (DB) techniques are mindfulness activities where through biofeedback, the respiratory rate lowers to 6-8 breaths per minute by increasing the expiratory phase of respiration. During inhalation, the vagal tone is depressed, and there is overall sympathetic overactivity. On the contrary, during exhalation, the vagal tone is restored; thus, by prolonging the expiratory phase, deep breathing techniques decrease sympathetic nervous system overactivity (Valensi, 2021; Magnon et al., 2021; Li et al., 2018). Additionally, several studies have been reported where voluntary DB techniques have aimed to treat CVD such as heart failure, hypertension, and arrhythmias, with promising results of better ejection fraction and significant heart rate reduction (Wu et al 2020).

By counting breaths, DB techniques can be performed with devices, mobile applications, or analog guidance. The RESPeRATE device is an FDA-approved medical device for the assistance of blood pressure control in the United States ("How RESPeRATE Works," n.d.). Systematic literature research reported that seven of thirteen studies assessed the efficacy of voluntary DB, while the rest assessed device-guided DB, with three utilizing the RESPeRATE device. The studies evaluating device-guided DB reported reductions of SBP and DBP of 6 to 8 mm Hg and 4 to 6 mm Hg, respectively, in both adults with elevated blood pressure and hypertensive patients who performed 15-30 minutes of the intervention daily. Half of said studies assessed 24-hr ambulatory BP and the rest assessed in-office average BP (Yau & Loke, 2021). A randomized clinical trial reported that lowering BP below 120 mmHg, compared to below 140 mmHg, resulted in a 25% lower relative risk of fatal and nonfatal cardiovascular events as well as death from any cause ("A Randomized Trial of Intensive versus Standard Blood-Pressure Control," 2015). One study also exhibited a remarkable lowering of SBP by 10.5 mm Hg and DBP by 7.5 mm Hg in patients with coronary artery disease and hypertension (D'silva 2014). However, 24-hr ambulatory BP measurements exhibited no significant variations in DBP in hypertensive patients and no overall BP variation in prehypertensive participants among reported studies. Cancer, pregnancy, stroke, chronic respiratory disease, and chronic renal failure population of adults with prehypertension or hypertension were population excluded in these studies (Yau & Loke, 2021).

Evidence regarding the efficacy of DBT is ambiguous because of the gap in the literature that still exists. Hereby in this review, we aim to assess the overall BP-lowering efficacy of breathing techniques in HTN. Secondary objectives include: (1) comparing the efficacy of de-vice-guided versus non-device-guided DBT, and (2) assessing the safety and adherence rate of DBT.

Materials and Methods

Search Strategy

Inclusion criteria were the following: (1) Participants with elevated blood pressure (also considered prehypertension, i.e., SBP 120-129 mm Hg and DBP < 80 mm Hg) and stage I or stage II hypertension (SBP 130-160 mm Hg or DBP > 80 mm Hg), (2) any breathing techniques as intervention, (3) randomized controlled trials (4) open access studies. To be excluded, the articles must have included a population $\geq$ 18 and $\leq$ 65 years of age, measured outcomes different than the mean reduction in systolic or diastolic blood pressure, and included patients with urgency and emergency hypertensive states.

Eligibility criteria

Inclusion criteria were the following: (1) Participants with elevated blood pressure (also considered prehypertension, i.e., SBP 120-129 mm Hg and DBP < 80 mm Hg) and stage I or stage II hypertension (SBP 130-160 mm Hg or DBP > 80 mm Hg), (2) any

breathing techniques as intervention, (3) randomized controlled trials (4) open access studies. To be excluded, the articles must have included a population $\geq$ 18 and $\leq$ 65 years of age, measured outcomes different than the mean reduction in systolic or diastolic blood pressure, and included patients with urgency and emergency hypertensive states.

Study selection process

The search question obtained the selected studies in PubMed and Cochrane sites. Most of the terms were filtered by title, abstract, and others by MESH. We did exclude terms like 'Yoga' and 'Qigong' exercise. The retrieved 119 studies were divided into five groups of two to three reviewers. They looked for the eligible articles by reading the Title, Abstract, Key Words, and, if necessary, the Methods section. If there were disagreements in the groups composed of two reviewers, another reviewer was consulted to eliminate the tie. A total of four studies were included. A flowchart of the literature search and selection process is shown in Fig. 1.

Study selection process

The search question obtained the selected studies in PubMed and Cochrane sites. Most of the terms were filtered by title, abstract, and others by MESH. We did exclude terms like 'Yoga' and 'Qigong' exercise. The retrieved 119 studies were divided into five groups of two to three reviewers. They looked for the eligible articles by reading the Title, Abstract, Key Words, and, if necessary, the Methods section. If there were disagreements in the groups composed of two reviewers, another reviewer was consulted to eliminate the tie. A total of four studies were included. A flowchart of the literature search and selection process is shown in Fig. 1.

Results

Data extraction

The included studies were reviewed by two authors each, and pertinent information regarding references, sample size, adherence, baseline characteristics, primary and secondary outcomes, study groups, comparisons, statistics used, effect or effect size, and drop on BP were tabulated in Table 1.

Study Characteristics

A total of 205 patients were assessed within the four articles included in this review. Three studies included stage II hypertensive patients (SBP >140 mm Hg or DBP >90 mm Hg), and one included both stage I (SBP 130-139 mm Hg or DBP 80-89 mm Hg) and stage II hypertensive participants. Three studies were conducted in Asia and one in America.

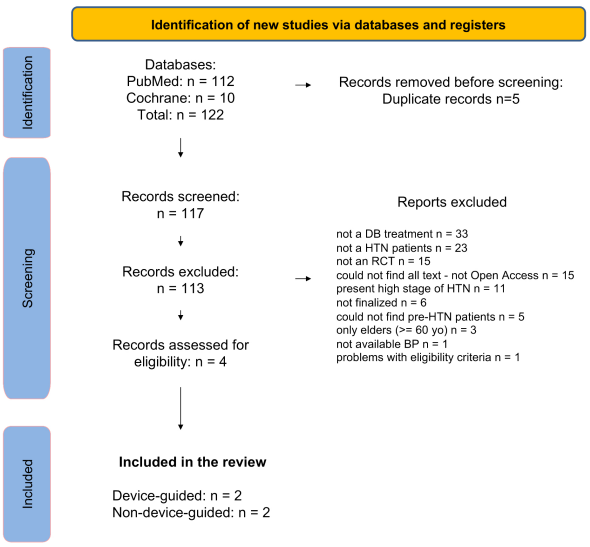

Figure 1: *Flowchart of the literature search process.*

Types of deep breathing techniques

Different deep breathing techniques were used in the four selected studies. A deep breathing device (RESPeRATE) was used in one of the studies (De Barros et al., 2017). Differently, one study used a simple loaded breathing device, the Water Pressure Threshold Bottle, developed in their laboratory (Jones et al., 2010). Another trial used a third technique consisting of listening to a music CD with incorporated sound cues to guide the patients into a regular breathing pattern with a breath rate of five breaths per minute (Kow et al., 2018). One article tested timed voluntary deep breathing through alternate nostril breathing cycles (Mourya et al., 2009).

Overall efficacy of deep breathing techniques

Out of the four studies, one found a significant SBP and DBP reduction in both the control and the intervention groups, with the control group showing a slightly more significant decrease in BP values. However, the absolute difference in SBP and DBP reduction from baseline was insignificant in both groups (Kow et al., 2018). Another study reported no significant difference in either SBP or DBP measured in the office setting associated with DB techniques; nonetheless, the authors reported a reduction in SBP and DBP in the awake period

Study authors / Location (year)	Study design	Sample size	Patients' diagnosis at baseline	Deep breathing intervention	Control group intervention	Intervention's length, frequency, and duration	Method of BP measurement	Change in SBP in the intervention group	Change in DBP in the intervention group	Further findings
Kow FP et al. / Malaysia (2018)	RCT	83	Stage 1 essential hypertension (SBP of 140–159 mmHg and DBP of 90–99 mmHg)	Voluntary DB listening to musical cues at a rate of 5 breaths per minute	Music listening with no breathing technique performance	15 min, daily, 8 weeks	Average of at least 3 office BP measurements	Mean reduction of 8.3 mmHg, p<0.05	Mean reduction of 5.6 mmHg, p<0.05	Reduction in MAP of 6.5 mmHg in the intervention group, p<0.05
de Barros S, et al. / Brazil (2017)	RCT	32	Mean 24-hr BP by ambulatory blood pressure monitoring (ABPM) above the normal range (SBP ≥ 130 mmHg and/or DBP ≥ 80mmHg)	RESPeRATE device-guided DB at <10 breaths/min	Listening to serene music with an MP3 player	10-15 min, daily, 8 weeks	Office BP measurements AND 24-hr ABPM	No change in office SBP before and after intervention in either group	No change in office DBP before and after intervention in either group	SBP and BPD reduction in awake 24-hr ABPM time in control group only (SBP 131 ± 10 mm Hg, DBP 92 ± 9 mm Hg vs SBP 128 ± 10 mm Hg, DBP 88 ± 8 mm Hg, p<0.05)
Mourya, M. et al. / India (2009)	RCT	60	Patients with essential HTN (SBP 140-159 mmHg and DBP 90-99 mmHg)	Alternate nostril slow-breathing cycles (5-6 breaths/min)	Fast-breathing group: breathing quickly and deeply (1 sec each phase) Control group: no intervention	15 min, daily, 12 weeks	Office BP measurements	Reduction in SBP from 146 mm Hg to 135 mm Hg, p<0.05	Reduction in DBP from 92 mm Hg to 85 mm Hg, p<0.05	In fast breathing group, reductions in SBP from 147 mm Hg to 144 mm Hg, p<0.05, and in DBP from 91 mm Hg to 90 mm Hg, p<0.05
Jones, C. U. et al. / Thailand (2010)	RCT	30	Essential hypertension stages I and II (SBP140–179 mmHg, DBP 90–109 mmHg)	Device-guided slow DB, either unloaded or breathing against a load of 20 cmH2O	Regular daily activities	30 min twice a day, daily, 8 weeks	Average of 7 twice daily "at home" BP measurements AND average of 2 laboratory BP measurements	Mean reduction of SBP of 13.5 mmHg (unloaded DB), p<0.05	Mean reduction of DBP of 7.0 mmHg (unloaded DB), p<0.05	Mean reduction of SBP of 18.8 mmHg and DBP of 8.6 mmHg (loaded DB), p<0.05

Table 1: *Studies included for this review of the literature regarding deep breathing techniques and their effect on blood pressure.*

by ambulatory blood pressure monitoring only in the control group (SBP 131 ± 10, DBP 92 ± 9 vs. SBP 128 ± 10, DBP 88 ± 8mm Hg, $p < 0.05$) (de Barros et al., 2017). One study that assessed DB guided by a self-made device reported a significant decrease in SBP and DBP with both loaded (against 20 cmH2O) and unloaded breathing (regular DB), with more significant reductions observed in the loaded breathing group (mean reduction of SBP of 13.5 mm Hg and DBP of 7.0 mm Hg) (Jones et al., 2010). Another trial reported a statistically significant decrease in both a group performing slow-breathing exercises and fast-breathing exercises, with the former showing more significant reductions (SBP 146 mm Hg to 135 mm Hg; DBP 92 mm Hg to 85 mm Hg) (Mourya et al., 2009).

Efficacy of device-guided deep breathing versus non-device-guided deep breathing

Two of the four studies included in this review of the literature utilized a breathing device to assist the DB technique intervention (Jones et al., 2010; de Barros et al., 2017). One of them used the RESPeRATE device and found no statistically significant difference in office BP with the device use but a statistically significant reduction in SBP and DBP in awake at-home BP measurement in the control group (listening to serene music with no breathing technique performance) (de Barros et al. 2017). One of the studies utilized a self-made breathing device developed at their laboratory and reported a reduction in home and laboratory SBP and DBP associated with the device's use (SBP, -9.3 mm Hg and -13.5 mm Hg, respectively; DBP, -5.9 mm Hg, and -7.0 mm Hg, respectively) (Jones et al., 2010).

Two studies assessed the efficacy of voluntary deep breathing. One of them instructed patients to follow music cues within a CD to reach a regular respiratory rate of five breaths per minute compared with music listening and no deep breathing technique and found a statistically significant reduction in both the intervention and control groups regarding SBP (mean systolic BP reduction, 8.3 mm Hg and 10.5 mm Hg, respectively) and DBP (mean diastolic BP reduction, 5.6 mm Hg and 5.2 mm Hg, respectively) (Kow et al., 2018). The other one trained the participants to perform alternate nostril breathing cycles and reported a statistically significant reduction in both SBP and DBP (Mourya et al., 2009).

Adherence and safety

The device-guided breathing techniques appear to be

safe. Three out of the four trials did not report the assessment of safety in their manuscripts (Mourya et al., 2009; Jones et al., 2010; de Barros et al., 2017). In one study, that tested the voluntary DB technique guided by music, two patients in the intervention group (5.1%) reported dizziness; in the control group, one (2.3%) complained of "numbness in the head" and one (2.3%) of irritability and palpitations (Kow et al., 2018).

The adherence to the device-guided DB technique was good. One trial reported a 95% adherence rate regarding the sessions in the control group and 93% in the device-guided DB group, according to patients' diaries (de Barros et al., 2017). On the other hand, two papers mentioned planned patients' adherence monitoring to the breathing protocol but did not report them (Mourya et al., 2009; Kow et al., 2018). Another one reports an approximate 95% adherence among all the patients who completed the study, with no specification among study groups (Jones et al., 2010).

Discussion

This manuscript summarizes the open-access evidence available on the efficacy of DBT for BP control. A key finding details three main deep breathing techniques assessed to improve BP. Similar to evidence in the literature, this review showed that deep breathing at respiratory rates < 10 breaths/min has decreased both SBP and DBP, irrespective of the guidance mechanism (Yau et al., 2021). However, these techniques have also failed to significantly affect BP lowering (de Barros et al., 2017). Another aspect highlighted here is the improvement in assessing and reporting adverse events and adherence rates in this field of investigation. Finally, all the trials included lasted less than 12 weeks; long-term assessment of the efficacy of these interventions needs to be improved.

Our review of the literature encompasses several limitations. Although PubMed is among the top research databases for medicine and healthcare matters, and Cochrane was also searched, other critical databases were not included in the systematic literature search. Moreover, only studies written in English and published in open-access journals were included, potentially affecting the authors' reach to the literature and introducing bias. Due to the reduced number of patients included and the need for more multicenter or other country studies, the results of this review lack generalizability. Specifically, the safety assessment of DB techniques was limited by the lack of information in 75% of the scientific papers included in this manuscript. Similarly, the inclusion of only four articles restricted conducting a robust comparison of the efficacy of non-device-guided and device-guided DB techniques.

Conclusions

Both device-guided and voluntary (non-device-guided) breathing techniques seem beneficial in lowering blood pressure in elevated blood pressure and stage I and II hypertension; however, 4 trials are insufficient for external validity. Therefore, future large-scale clinical trials assessing the long-term effectiveness of these interventions in the stated populations, especially elevated blood pressure and stage I hypertension, are recommended.

Supplementary Materials

The following supporting information can be read along at the end of this document.

Author Contributions

Conceptualization, KLPB, DA, FL, AFT, ASGB, AJA, BAO, GAM, GYGN, LMB, MF, TOA, and RUP.; methodology, KLPB, DA, FL, AFT, ASGB, AJA, BAO, GAM, GYGN, LMB, MF, TOA, and RUP.; software, KLPB, DA, FL, GAM, MF.; validation, KLPB, DA, FL, AFT, GYGN, GAM, RUP; formal analysis, KLPB, DA, FL, ASGB, AJA, BAO, GAM, LMB, MF, TOA, RUP; investigation, KLPB, DA, AFT, AJA, GAM, LMB, MF, TOA, and RUP.; resources, AFT, ASGB, AJA, BAO, GAM, GYGN, LMB, MF, and TOA.; data curation, KLPB, DA, FL, ASGB, AJA, GAM, LMB, MF, and RUP.; writ-ing—original draft preparation, KLPB, DA, FL, GAM, and RUP.; writing—review and editing, KLPB, DA, FL, AFT, ASGB, AJA, BAO, GAM, GYGN, LMB, MF, TOA, and RUP.; visualization, KLPB, DA, FL, GAM, GYGN, LMB, MF, TOA, and RUP.; supervision, KLPB, DA, FL, GAM, and RUP.; project administration, KLPB, DA, FL, AFT, ASGB, AJA, BAO, GAM, GYGN, LMB, MF, TOA, and RUP. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

- A Randomized Trial of Intensive versus Standard Blood-Pressure Control. (2015). New England Journal of Medicine, 373(22), 2103–2116. https://doi.org/10.1056/NEJMoa1511939

- Al-Makki, A., DiPette, D., Whelton, P. K., Murad, M. H., Mustafa, R. A., Acharya, S., Beheiry, H. M., Champagne, B., Connell, K., Cooney, M. T., Ezeigwe, N., Gaziano, T. A., Gidio, A., Lopez-Jaramillo, P., Khan, U. I., Kumarapeli, V., Moran, A. E., Silwimba, M. M., Rayner, B., & Sukonthasan, A. (2021). Hypertension Pharmacological Treatment in Adults: A World Health Organization Guideline Executive Summary. https://doi.org/10.1161/ HYPERTENSIONAHA.121.18192
- de Barros, S., da Silva, G. V., de Gusmão, J. L., de Araújo, T. G., de Souza, D. R., Cardoso, C. G., Oneda, B., & Mion, D. (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
- F. D'silva, H. Vinay, N.V. Muninarayanappa, (2014) Effectiveness of deep breathing exercise (DBE) on the heart rate variability, BP, anxiety and depression of patients with coronary artery disease. J. Health Sci. 4 (35). https://doi.org/10.1055/s-0040-1703728
- Fonkoue, I. T., Marvar, P. J., Norrholm, S. D., Kankam, M. L., Li, Y., DaCosta, D., Rothbaum, B. O., & 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), H141–H149. https://doi.org/10.1152/ajpheart.00098.2018
- Foreman, K. J., Marquez, N., Dolgert, A., Fukutaki, K., Fullman, N., McGaughey, M., Pletcher, M. A., Smith, A. E., Tang, K., Yuan, C.-W., Brown, J. C., Friedman, J., He, J., Heuton, K. R., Holmberg, M., Patel, D. J., Reidy, P., Carter, A., Cercy, K., … Murray, C. J. L. (2018). Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: Reference and alternative scenarios for 2016–40 for 195 countries and territories. Lancet (London, England), 392(10159), 2052–2090. https://doi.org/10.1016/S0140-6736(18)31694-5
- Forouzanfar, M. H., Afshin, A., Alexander, L. T., Anderson, H. R., Bhutta, Z. A., Biryukov, S., Brauer, M., Burnett, R., Cercy, K., Charlson, F. J., Cohen, A. J., Dandona, L., Estep, K., Ferrari, A. J., Frostad, J. J., Fullman, N., Gething, P. W., Godwin, W. W., Griswold, M., … Murray, C. J. L. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: A systematic analysis for the Global Burden of Disease Study 2015. The Lancet, 388(10053), 1659–1724. https://doi.org/10.1016/S0140-6736(16)31679-8
- Fu, J., Liu, Y., Zhang, L., Zhou, L., Li, D., Quan, H., Zhu, L., Hu, F., Li, X., Meng, S., Yan, R., Zhao, S., Onwuka, J. U., Yang, B., Sun, D., & Zhao, Y. (2020). Nonpharmacologic Interventions for Reducing Blood Pressure in Adults With Prehypertension to Established Hypertension. Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease, 9(19), e016804. https://doi.org/10.1161/JAHA.120.016804
- Hamasaki, H. (2020). Effects of Diaphragmatic Breathing on Health: A Narrative Review. Medicines (Basel, Switzerland), 7(10), E65. https://doi.org/10.3390/medicines7100065
- Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.3 (updated February 2022). Cochrane, 2022. Retrieved November 3, 2022, from https://training.cochrane.org/handbook/current
- Huang, Y., Cai, X., Liu, C., Zhu, D., Hua, J., Hu, Y., Peng, J., & Xu, D. (2015). Prehypertension and the Risk of Coronary Heart Disease in Asian and Western Populations: A Meta-analysis. https://doi.org/10.1161/JAHA.114.001519
- Mourya, M., Mahajan, A. S., Singh, N. P., & Jain, A. K. (2009). Effect of Slow- and Fast-Breathing Exercises on Autonomic Functions in Patients with Essential Hypertension. The Journal of Alternative and Complementary Medicine, 15(7), 711–717. https://doi.org/10.1089/acm.2008.0609
- Magnon, V., Dutheil, F. & Vallet, G.T. Benefits from one session of deep and slow breathing on vagal tone and anxiety in young and older adults. Sci Rep 11, 19267 (2021). https://doi.org/10.1038/s41598-021-98736-9
- RESPeRATE Inc. © How It Works. (2021). RESPeRATE To Lower Blood Pressure. All Right Reserved. Site updated 2021/11/22. Retrieved November 3, 2022, from https://www.resperate.com/how-it-works/
- Jones, C. U., Sangthong, B., & Pachirat, O. (2010). An inspiratory load enhances the antihypertensive effects of home-based training with slow deep breathing: A randomised trial. Journal of Physiotherapy, 56(3), 179–186. https://doi.org/10.1016/S1836-9553(10)70023-0

- Kow, F. P., Adlina, B., Sivasangari, S., Punithavathi, N., Ng, K. K., Ang, A. H., & Ong, L. M. (2018). The impact of music guided deep breathing exercise on blood pressure control - A participant blinded randomised controlled study. The Medical journal of Malaysia, 73(4), 233–238. https://pubmed.ncbi.nlm.nih.gov/30121686/
- Li, C., Chang, Q., Zhang, J., & Chai, W. (2018). Effects of slow breathing rate on heart rate variability and arterial baroreflex sensitivity in essential hypertension. Medicine, 97(18), e0639. https://doi.org/10.1097/MD.0000000000010639
- Wu, Q., Liu, L., Jiang, X., Hu, Y.Y., Liang, Q.S., He, Z.S., Xue, Y., Zhu, W., Tang, Z.X., Hou, Y.Y., Zhao, Q., Wang, X.H. (2020) Effect of voluntary breathing exercises on stable coronary artery disease in heart rate variability and rate-pressure product: a study protocol for a single-blind, prospective, randomized controlled trial. Trials 21(602). https://doi.org/10.1186/s13063-020-04402-2
- Valensi, P. (2021). Autonomic nervous system activity changes in patients with hypertension and overweight: Role and therapeutic implications. Cardiovascular Diabetology, 20(1), 170. https://doi.org/10.1186/s12933-021-01356-w
- Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Dennison Himmelfarb, C., DePalma, S. M., Gidding, S., Jamerson, K. A., Jones, D. W., MacLaughlin, E. J., Muntner, P., Ovbiagele, B., Smith, S. C., Spencer, C. C., Stafford, R. S., Taler, S. J., Thomas, R. J., Williams, K. A., … Wright, J. T. (2018a). 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension, 71(6), e13–e115. https://doi.org/10.1161/HYP.0000000000000065
- Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Dennison Himmelfarb, C., DePalma, S. M., Gidding, S., Jamerson, K. A., Jones, D. W., MacLaughlin, E. J., Muntner, P., Ovbiagele, B., Smith, S. C., Spencer, C. C., Stafford, R. S., Taler, S. J., Thomas, R. J., Williams, K. A., … Wright, J. T. (2018b). 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension, 71(6), 1269–1324. https://doi.org/10.1161/HYP.0000000000000066
- World Health Organization. (2021) Hypertension. August 25th. Retrieved November 3, 2022, from https://www.who.int/news-room/fact-sheets/detail/hypertension
- Wu, Y., Senk, C., Coll, P., Glenney, S., Zaborowski, K., Fortinsky, R., Taylor, B., Park, C., Benson, K., McGowan, M., DiBiasi, S., Chen, M.-H., & Pescatello, L. (2021). A comparison of two Tai Chi interventions tailored for different health outcomes. Complementary Therapies in Medicine, 59, 102731. https://doi.org/10.1016/j.ctim.2021.102731
- Yau, K. K.-Y., & 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. https://doi.org/10.1016/j.ctcp.2021.101315