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The Impact of Breathing Exercises on Heart Rate Variability in Hypertensive Individuals: A Systematic Review

Karthiga J[1]
Dept. of Physiology
JIPMER
Karaikal, India

Arunkumar B[2]
Dept. of Physiology
JIPMER
Karaikal, India

Abstract:-

A. Introduction

Hypertension (HTN), owing to high prevalence rate poses a significant health threat. Untreated HTN is a major risk factor for developing coronary artery disease. However, early intervention reduces the risk of complication. Breathing exercises (BE) has been gaining importance due to its potential role in enhancing autonomic function in HTN. This systematic review aims to evaluate the impact of BEs on heart rate variability (HRV), a clinical marker of autonomic nervous system function, in patients with HTN.

B. Objective

To assess the impact of different types of BE used in management of HTN and their effects on HRV parameters.

C. Methodology

Studies evaluating the changes in HRV following BE involving hypertensive individuals, aged 18-70 years of both sexes were included in the review. Data were extracted from various scientific database. Risk of bias was assessed using standard protocol and the results were analysed.

D. Results:

A total of 7 studies, including both Randomized Control Trials and observational studies, were analyzed. Following the BE, the studies demonstrated significant improvements in HRV, with increased parasympathetic activity (higher RMSSD, SDNN, pNN50, and HF) and a reduction in the LF: HF ratio. Despite the type and duration of breathing techniques that were employed, all were found to be beneficial in improving autonomic function.

E. Discussion:

BE significantly enhance vagal tone, which helps in the reduction of blood pressure. The results suggest that regular practice of BEs would serve as an adjuvant therapy in treating HTN. However, more robust study with huge sample size and standard protocol are essential to study the long-term effects of BE on autonomic function in hypertensive individuals.

Keywords:- *Breathing Exercise, Heart Rate Variability, Hypertension.*

I. INTRODUCTION

➢ *Rationale:*

Hypertension (HTN), a non- communicable disease is characterized by elevated blood pressure. It poses a major health threat globally owing to the high prevalence rate. The prevalence of HTN estimated in India about 24 – 30% (1). The prime concern is that many individuals are not aware of this condition unless they experience serious complications like coronary artery disease (CAD), cerebrovascular accidents (CVA) or renal failure (2).

Though HTN is a serious health ailment, it is still a modifiable risk factor. Therefore, early diagnosis and prompt treatment, along with life style modification is advocated to prevent the progression of the disease and promote health (3). “Yoga”, an ancient Indian art of living is becoming increasingly popular method of intervention in promoting health of individuals with HTN.

Autonomic imbalance is reported in hypertensive individuals, which is attributed to cause heart diseases (4). Breathing exercises, a key component of Yoga have been proven to improve the autonomic function (5). Hence, in this study we planned to review studies that evaluate the effects of breathing exercises on heart rate variability (HRV) reflecting the autonomic function in patients with HTN.

➢ *Objective:*

Our review aims to answer the research question:

- What are the different types of breathing exercise practised in treating HTN and their effects on HRV parameters?

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II. METHODOLOGY

A. Eligibility Criteria

➢ *Inclusion Criteria:*

This review includes studies (published in English) involving hypertensive subject (aged 18-70 years of either sex), which assessed the heart rate variability measures after the practice of breathing exercises like Sheetali, Sheetkari, Nadishodana, Bhramari (Bee humming breathing) pranayama and slow breathing technique.

➢ *Exclusion Criteria:*

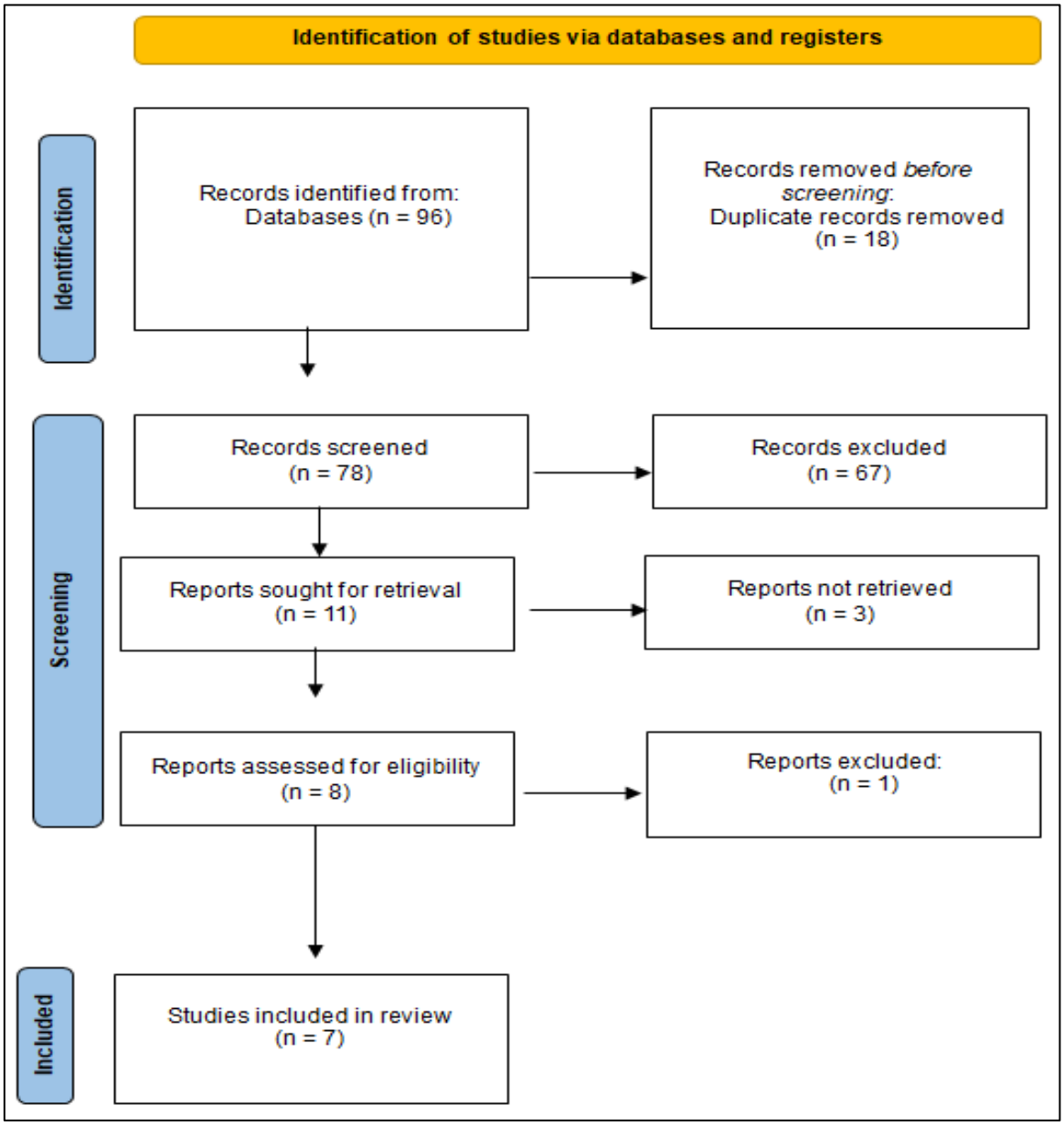
Studies involving patients with secondary cause of HTN or any other co-morbidities were excluded. Studies focusing on physical exercises or yoga asanas are excluded.

B. Information Sources

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Sources were assessed from various database like "PubMed", "Cochrane Library", "Scopus", and "Google Scholar" that were published till November 2024, using terms like *"Breathing exercises" OR "pranayama" OR "yogic breathing" AND ("hypertension" OR "high blood pressure") AND ("heart rate variability" OR "autonomic function")*

C. Screening and data extraction:

After duplicate removal, title and abstracts were screened. Relevant full-text articles were checked to meet the inclusion/ exclusion criteria as depicted in *figure no.1*. Two independent reviewers assessed the studies. The key data that were extracted from the studies are tabulated in *table no. 3*. The results interpreted the changes in HRV parameters following breathing exercise.



Fi 1: Study Procedure

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D. Risk of Bias:

The risk of bias for the studies that were included in the research are tabulated in table 1 and 2.

The **"***Cochrane Risk of Bias Tool* **(RoB 2)"** was used to assess the risk of bias in the Randomized control trials (RCT), that were included in the review. It evaluates the risk across five domains. Each domain is rated as low, moderate, or high risk of bias. The overall risk of bias for each study is determined by the highest rating across domains.

Table 1: Risk of Bias of RCT studies

First author	Randomization bias	Deviation from intended intervention	Incomplete outcome data	Selective reporting	Other bias	Overall risk of bias	Justification
Thanalakshmi et al.	Low	High*	Low	Low	Low	Low	Blinding not possible due to nature of intervention
Yuenyongchaiwat et al.	Low	High*	Low	Low	Low	Low	Blinding not possible due to nature of intervention
Ghati et al.	Low	High *	Low	Low	Low	Moderate	Blinding not possible, No clarity on missing data and allocation concealment
Shetty et al.	Low	High*	Unclear	Unclear	Low	High	Blinding not possible; However other details remain unclear
Upadhyay et al.	Low	High*	Low	Unclear	Low	High	Blinding not possible; High risk of selection and performance bias

*The "High" ratings in the "Deviations from Intended Interventions" domain are due to the nature of interventions, rather than methodological flaws.

The **ROBINS-I tool** (Risk Of Bias In Non-randomized Studies - of Interventions) assesses the risk of bias in non-randomized studies, containing seven domains. Each domain is rated as having low, moderate, serious, or critical risk of bias. The overall risk of bias for each study is based on the highest rating across the domains.

Table 2: Risk of Bias of non-RCT studies

First Author	Selection Bias	Intervention classification Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Confounding Bias	Overall Risk of Bias	Justification
Li et al.	Moderate	Low	Low (with investigator blinding)	Moderate	Low	Moderate	Moderate	Moderate	Due to study design
Pinheiro et al.	High	Moderate	Unclear	High	Unclear	Low	Low	High	Sample was selected based on clinical follow-up forms, and no random selection

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III. RESULTS

Table no.3- Summary of the studies:

Study	Author(s) (Year)	Study Design	Sample Size	Intervention	Frequency and duration	HRV Measures	Key Findings
1.	Thanalakshmi et al. (2020)	RCT	100 HTN patients (study group =50, control group= 50)	Sheetali Pranayama	30 minutes/ day for 3 months	SDNN, RMSSD, p NN50, HF, LF LF: HF	Significant increase in SDNN, RMSSD, pNN50, HF and significant reduction in LF, LF: HF
2.	Yuenyongchaiwat et al. (2024)	RCT	100 HTN patients (study group =50, control group= 50)	Slow Breathing Training	15 minutes/ day for 1 month	SDNN, RMSSD, pNN50, HF, LF, LF: HF	Significant increase in SDNN
3.	Ghati et al. (2021)	RCT	75 HTN patients (study group =35, placebo group= 35)	Bee-Humming Breathing	5 minutes (one session)	SDNN, RMSSD, pNN50, HF, LF, LF: HF	Significant increase in HF and significant reduction in LF
4	Shetty et al. (2017)	RCT	60 HTN patients (study group = 30, control group= 30)	Sheetali & Sheetkari Pranayama's	10 minutes/ day for 1 month	SDNN, RMSSD, pNN50, HF, LF, LF: HF	Significant increase in NN50, p NN50, HF and significant reduction in LF:HR
5.	Upadhyay et al. (2023)	RCT	100 HTN patients (Nadishodhana =50, Bhramari= 50)	Nadishodhana Vs Bhramari	20 minutes (one session)	RMSSD, pNN50, HF, LF, LF: HF	Significant increase in RMSSD and significant reduction in LF: HF in both groups.
6.	Li et al. (2018)	Observational	120 subjects (study group = 60, healthy control group= 60)	Slow Breathing	8 breaths/ minute for 5 minutes (single session)	HF, LF, LF: HF	Significant increase in HF and significant reduction in LF, LF: HF
7.	Pinheiro et al. (2007)	Observational	10 HTN patients	Slow breathing training	30 minutes, twice a week for 4 weeks	SDNN, pNN50	Significant increase in SDNN

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SDNN: Standard Deviation of NN Intervals, RMSSD: Root Mean Square of Successive Differences, pNN50: Percentage of Successive NN Intervals that differ by more than 50 ms, HF: High-Frequency Power, LF: Low-Frequency Power, LF: HF: Ratio of Low-Frequency to High-Frequency Power

IV. DISCUSSION

Though the studies reviewed by us employed different breathing exercises with varying duration, all the researches demonstrated an increase in parasympathetic activity, which were evident with increase in time domain parameters like RMSSD, SDNN, pNN50 and HF power in frequency domain. Also, there was decreased LF:HF ratio suggesting sympatho-vagal imbalance.

A. Intervention with Short Duration:

After a single short session (5-minute) of Bee-Humming Breathing, Ghati et al. reported an increase in HF and a reduction in LF, indicating that even after intervention for a short duration, vagal activity was enhanced (6). This finding was supported by the earlier study carried out by Li et al., which showed a significant increase in HF and a reduction in LF following a short session (5-minutes) of slow breathing (7).

B. Intervention with Long Duration:

Thanalakshmi et al. found significant parasympathetic dominance in HRV parameters (statistically significant increase in pNN50%, RMSSD, SDNN and HF power) after 3 months of practice of Sheetali Pranayama, demonstrating the long-term benefits of breathing exercises in hypertensive patients (8). Similarly, study carried out by Yuenyongchaiwat et al. demonstrated significant increase in RMSSD after 1 month of slow breathing training program (9). Improvement in HRV parameters were demonstrated by Shetty et al., where Sheetali and Sheetkari Pranayama's were advocated to HTN subjects (10). Also, slow breathing technique practised for a period of 1 month demonstrated a significant increase in SDNN suggestive of parasympathetic dominance (11).

C. Comparing Techniques:

Though different breathing techniques were employed, all were proven to be beneficial in autonomic regulation. As in the study carried out by Upadhyay et al. comparing the benefits of Nadishodhana and Bhramari pranayama, both demonstrated an increase in RMSSD along with reduction in LF: HF, while there was also an increase in HF power in group practising Bhramari pranayama (12).

D. Mechanism:

The improvements in HRV parameters by breathing exercises are majorly due to the enhancement of *vagal tone.* This improvement in parasympathetic activity also reduces BP levels (13).

E. Clinical Implications for Hypertension Management:

The findings of the above-mentioned studies supports that the breathing exercises can be used as a potential complementary tool in addition to regular medication for hypertension management, to achieve a state of sympatho-vagal balance which could offer a cost-effective strategy for better cardiovascular health in patients with HTN (14).

F. Limitations:

- *Sample Size:*

Most of the studies had small sample sizes. Future research should include larger groups to aid in the generalization of the findings.

- *Standard Protocol:*

Studies varied in duration, frequency, type of breathing exercise. Developing standardized protocols would yield more consistent findings.

- *Duration of Study:*

Longitudinal studies are needed to assess the long-term effects of breathing exercise on HRV in subjects with HTN.

- *Underlying- Mechanism:*

Inclusion of biochemical parameters would be beneficial to understand the mechanism.

G. Future Directions:

Multicentric-RCTs with standardized protocols and follow-ups are essential to assess the long-term benefits of breathing exercise on HRV in hypertensive subjects.

V. CONCLUSION

This systematic review supports the benefits of breathing techniques on HRV in hypertensive patients. By increasing parasympathetic activity and improving the sympathovagal balance, breathing exercise thereby improves cardiovascular health. These findings suggest that breathing exercise will be an effective and complementary approach in reducing cardiovascular risk of patients with HTN.

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