International Research Journal of Ayurveda & Yoga Vol. 7(12), pp. 30-41, October, 2024
Available online at http://irjay.com
ISSN: 2581-785X
DOI: 10.48165/IRJAY.2024.71205

Editorial

The Impact of Yoga on Heart Rate Variability: *A Systematic Review of Randomized Controlled Trials*

Selvaraj Giridharan[1], Jawaher Ansari[2], Hari Pannerselvam[3]

1- Consultant Oncologist.Department of Medical Oncology Tawam Hospitals Al Ain, UAE
2- Consultant Oncologist.Department of Medical Oncology Tawam Hospitals Al Ain, UAE
3- Specialist Registrar in Gastroenterology Worcestershire Acute Hospitals NHS trust WorcetserUnited Kingdom

ARTICLE INFO

Article history:
Received on: 06-10-2024
Accepted on: 07-12-2024
Published on: 31-12-2024

Keywords: *Heart Rate Variability (HRV), Yoga, Autonomic Regulation, Chronic Conditions, Parasympatheticetic Activity*

ABSTRACT

Background: Heart rate variability (HRV) serves as an indicator of autonomic nervous system function, reflecting the balance between sympathetic and parasympathetic activities. Elevated HRV is associated with enhanced cardiovascular health and resilience to stress, while reduced HRV correlates with adverse health outcomes, including cardiovascular disease, metabolic disorders, and mental health conditions. Yoga, an ancient mind-body practice, has the potential to enhance HRV by improving autonomic regulation. This review aims to evaluate the impact of yoga on HRV in both healthy individuals and clinical populations.

Methods: A systematic search was conducted across the Cochrane Library, PubMed, Scopus, and Web of Science databases for randomized controlled trials (RCTs) published between 2015 and 2024. Eligible studies were required to assess the effects of yoga on HRV in diverse populations. Data extraction focused on the characteristics of the interventions, HRV metrics, and outcomes. The quality of the studies was assessed using the Cochrane Risk of Bias Tool.

Results: A total of twenty-three studies were included in this review. Findings indicated that yoga interventions improved HRV in participants with cardiovascular conditions, metabolic syndrome, and chronic pain, as evidenced by increased high-frequency (HF) power and a reduced low-frequency to high-frequency (LF/HF) ratio, which suggest enhanced autonomic function. Results regarding mental health populations were heterogeneous, with some demonstrated improvements in HRV, while data from healthy individuals indicated limited changes in HRV, suggesting that yoga may be particularly beneficial for patients with autonomic dysfunction. The quality of the studies varied, with notable limitations pertaining to blinding and sample size.

Conclusion: Yoga may have the potential to improve HRV, particularly among patients with chronic conditions. However, the inconsistent findings observed in mental health and healthy populations underscore the necessity for standardized interventions and further research. This review provides support for the incorporation of yoga as a complementary approach aimed at enhancing autonomic function and overall well-being.

1. INTRODUCTION

Heart rate variability (HRV) is the variation in time between consecutive heartbeats, also known as inter-beat intervals (IBIs). It reflects the balance between the sympathetic and parasympathetic branches of the autonomic nervous system (ANS). HRV provides valuable insights into how well the body adapts to stress and maintains its homeostasis. As a dynamic measure of autonomic function, HRV has emerged as a biomarker for physical and mental well-being.[1,2]A high HRV indicates greater flexibility and a healthier autonomic

Corresponding author
Selvaraj Giridharan,
Consultant Oncologist.Department of Medical Oncology Tawam Hospitals Al Ain, UAE
E-mail address: selvagiri@icloud.com

balance, reflecting the ability to efficiently switch between sympathetic and parasympathetic responses.[3] Conversely, low HRV reflects impaired autonomic regulation, which has been associated with adverse outcomes such as cardiovascular diseases, metabolic disorders, chronic stress, anxiety, and depression. These patterns highlight the importance of HRV as both a diagnostic tool and a potential therapeutic target in a variety of health contexts.[4]

The ANS plays a crucial role in regulating vital functions, such as heart rate, blood pressure, respiration, and digestion. Reduced HRV indicates sympathetic dominance and diminished parasympathetic activity, exacerbating symptoms and persistence in mental health disorders such as depression, anxiety, and chronic stress.[5,6] In cardiovascular diseases, low HRV is linked to a higher risk of arrhythmias, heart failure, and sudden cardiac death, owing to impaired autonomic regulation. Similarly, in metabolic and respiratory disorders, reduced HRV reflects disruption of glucose metabolism, insulin sensitivity, and increased inflammation, further contributing to disease progression.[7-10]

Improving HRV has become a therapeutic goal, owing to its broad health implications. Aerobic exercise enhances HRV by promoting a better balance between sympathetic and parasympathetic systems. Mindfulness practices, such as meditation and yoga, boost parasympathetic activity while reducing sympathetic responses and promoting relaxation.[11] Additionally, HRV biofeedback assists individuals in regulating their stress responses by providing real-time feedback on their physiological state, thereby enabling them to modulate autonomic function effectively.

Yoga is a mind-body practice that integrates physical postures (asanas), breathing techniques (pranayama), and meditation to foster mental and physical harmony.[12,13] The potential of yoga to positively influence HRV stems from its capacity to enhance parasympathetic activity while reducing sympathetic overactivity, thereby facilitating autonomic regulation. Consequently, yoga has been increasingly adopted as a complementary intervention in healthcare settings, with growing research interest in its ability to improve HRV across diverse populations.[14,15]

Posadzki et al. and Tyagi et al. investigated the relationship between yoga and HRV, providing valuable insights despite research heterogeneity, methodological limitations, and inconsistent results, thus precluding definitive conclusions.[16,17] Considering the rapid expansion of yoga research, this review addressed previous limitations by focusing on recent RCTs, assessing the effects of yoga on HRV in healthy individuals and those with physical or mental health conditions, and examining the impact of various yoga practices and intervention durations on HRV.

2.METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and rigor throughout the review process.[18]

Inclusion and exclusion criteria: The eligibility criteria for this review were RCTs conducted on healthy individuals or those with physical or mental health conditions. The intervention had to involve any form of yoga practice, including physical posture, breathing techniques, meditation, or integrated yoga practice. Studies needed to report HRV outcomes measured using time-domain parameters, such as the root mean square of successive differences (RMSSD) and the standard deviation of normal-to-normal intervals (SDNN), frequency-domain metrics, low-frequency (LF) and high-frequency (HF) power, and the LF/HF ratio. Only articles published in English between 2015 and 2024 were eligible for inclusion. Non-RCT studies, conference abstracts without full text, and studies that did not report HRV outcomes were excluded.

Search Strategy, Study Selection, and Data Extraction: The search strategy involved a comprehensive search of the Cochrane Library, PubMed, Scopus, and Web of Science databases. The study selection process consisted of three stages. First, two independent reviewers screened the titles and abstracts of all the identified studies to determine their relevance. In the second stage, potentially eligible studies were subjected to a full-text review to confirm that they met the inclusion criteria. Any disagreements between the reviewers during these stages were resolved through discussion or consultation with a third reviewer when necessary. The entire selection process was documented using the PRISMA flow diagram. The extracted data included study details, population characteristics, and intervention specifics (e.g., yoga type, duration, frequency, and setting). Additionally, the control group details and HRV outcomes (for example, RMSSD, LF/HF ratio, and HI measurement tools) were recorded along with the key findings of each study.

Risk of Bias Assessment: The Cochrane Risk of Bias Tool was used to evaluate the methodological quality of the included RCTs.[19]

3.RESULTS

A total of 637 studies were retrieved from the PubMed, Cochrane Library, Web of Science, and Scopus databases. After removing 45 duplicates, 592 articles were screened based on their titles and abstracts. Of these, 545 were excluded as they did not meet the inclusion criteria. The remaining 47 full-text articles were assessed for eligibility, resulting in 23 studies being included in the final systematic review. A PRISMA flow diagram depicting the study selection process is provided in Figure 1. These studies evaluated the impact of various yoga interventions on HRV in both healthy individuals and those with diverse physical and mental health conditions and used a range of HRV metrics, including time-domain measures such as RMSSD and SDNN and frequency-domain measures such as LF, HF,

and the LF/HF ratio. The attached table contains summary characteristics of the included studies [Table 1]. We discuss the findings below, grouped by clinical condition, to provide a clearer summary.

Metabolic and Cardiovascular Conditions: In individuals with metabolic syndrome, Kim et al. found that postmenopausal women practicing yoga for 12 weeks experienced a reduction in LF power, indicating decreased sympathetic activity; however, other HRV parameters showed no significant differences between the yoga and control groups. Similarly, Danasegaran et al. reported that participants incorporating yoga into their treatment plans exhibited an increase in the total power of HRV and a reduction in the LF/HF ratio, signaling a shift towards improved autonomic balance and metabolic regulation. [21] For individuals with hypertension, Punita et al. demonstrated significant improvements in HRV metrics with enhanced SD1 and SD2 values (analyzed using Poincaré plot analysis), indicating improved parasympathetic activity and autonomic balance. [22] Additionally, Balamadhuwanthi et al. reported that healthcare workers practicing chair yoga experienced reduced stress and improved HRV, reinforcing the potential benefits of yoga on cardiovascular and autonomic health. [23]

Patil et al. evaluated the impact of yoga on cardiac autonomic dysfunction and insulin resistance in non-diabetic offspring of parents with type 2 diabetes. Their results showed improved HRV parameters, including increased HF, decreased LF, and a reduced LF/HF ratio.[24] Additionally, the participants exhibited better insulin sensitivity, with reductions in fasting glucose and oral glucose tolerance test scores. These findings suggest that yoga may reduce the risk of diabetes by improving autonomic function and metabolic regulation in high-risk individuals. Archana et al. investigated the effects of Om chanting and Yoga Nidra on mental health, sleep quality, and HRV in individuals with hypertension.[25] The experimental group experienced significant reductions in depression, anxiety, and stress levels, along with improvements in sleep quality and HRV parameters, reinforcing the role of yoga in both mental and autonomic regulation.

In cardiovascular rehabilitation, Christa et al. evaluated patients recovering from myocardial infarction and found that a 12-week yoga-based cardiac rehabilitation program significantly enhanced HRV.[26] The participants exhibited increased HF power and TP, reflecting improved parasympathetic function and autonomic regulation. Although Guthrie et al. reported no significant HRV changes in perimenopausal women with vasomotor symptoms following yoga intervention, these findings suggest that the effect of yoga on HRV may vary across different populations. [27]

Chronic Pain and Rheumatoid Arthritis: Telles et al. demonstrated that yoga significantly reduced LF power while increasing HF power and pNN50, indicating a shift towards vagal dominance in patients with chronic low back pain.[28] Similarly, Ganesan et al. found that a 12-week yoga intervention in individuals with rheumatoid arthritis improved autonomic function, which was marked by an increase in HF power and a reduction in the LF/HF ratio. These changes were accompanied by a reduction in disease activity.[29]

Mental Health Conditions: Gulati et al. observed that yoga therapy reduced the LF/HF ratio in patients with major depressive disorder, suggesting improved autonomic regulation, although other HRV parameters did not show significant changes.[30] Lin et al. reported that 12 weeks of yoga reduced stress and improved HRV among mental health professionals, supporting yoga as an effective intervention for stress management in high-stress environments.[31] Chu et al. further demonstrated that yoga improved depressive symptoms and enhanced parasympathetic function in women, emphasizing its therapeutic potential for mood regulation.[32] However, findings across various mental health conditions are inconsistent, indicating the need for further research to elucidate the variability in outcomes.

Neurological and Musculoskeletal Conditions: Dhargave et al. examined the impact of combining yoga with physiotherapy in individuals with Duchenne Muscular Dystrophy and reported improvements in high-frequency power, indicative of enhanced parasympathetic activity.[33] However, the benefits were comparable to those of physiotherapy alone, suggesting that, although yoga provides additional support, it may not offer superior effects in this population. Chu et al. investigated the impact of acute yoga sessions and found no significant changes in HRV compared with quiet sitting, highlighting that single yoga sessions may not be sufficient to produce measurable autonomic shifts.[34]

Nagendra et al. explored the effect of yoga on cognitive function and autonomic regulation in healthy young individuals. Their findings revealed that yoga led to better autonomic regulation, as reflected by increased SDNN/RMSSD values and a lower LF/HF ratio, suggesting enhanced parasympathetic activity.[35] Lalitha et al. examined the immediate effects of Kapalbhati Pranayama on short-term HRV in healthy volunteers. While Kapalbhati initially caused parasympathetic withdrawal, HRV measures shifted towards parasympathetic dominance after a 20-minute recovery period, highlighting the dynamic nature of autonomic responses to Pranayama practices.[36] Odynets et al. evaluated the effects of a 12-month yoga intervention in breast cancer survivors and reported significant improvements in HRV metrics, including SDNN, RMSSD, and HF power. These findings suggest that long-term yoga practice enhances parasympathetic activity, reduces stress, and improves the quality of life for cancer patients.[37]

Healthy Individuals: Hewett et al. explored the impact of Bikram yoga on stressed and sedentary adults and found no significant changes in HRV, although participants exhibited improvements in secondary outcomes such as blood pressure and body composition. This finding suggests that Bikram yoga offers physical health benefits, although its influence on

autonomic regulation may be limited.[38] Similarly, Thrower et al. reported mixed HRV outcomes following Vinyasa yoga, with a transient sympathetic response immediately post-session, but observed favorable reductions in blood pressure, reinforcing yoga's cardiovascular benefits.[39] Maheshkumar et al. also demonstrated that yoga breathing practices enhance parasympathetic function in healthy adolescents, suggesting that regular yoga practice can promote cardiovascular health, even if immediate HRV improvements remain limited.[40] Chu et al. investigated the effect of a single yoga session on acute stress responses and found no significant differences in HRV compared to quiet sitting during stress recovery.[41] This indicates that immediate autonomic changes may not occur with isolated sessions and that prolonged or more intensive practice may be necessary to elicit significant autonomic shifts. Pakulanon et al. studied the effects of yoga and mindfulness meditation on stress-related variables in healthy individuals.[42] Their findings showed a decrease in LF power and an increase in HF power, indicating a shift towards parasympathetic dominance, suggesting that these practices help mitigate stress through enhanced autonomic regulation.

Risk of Bias Assessment: The Cochrane Risk of Bias Tool was used to evaluate the methodological quality of the 23 included RCTs, focusing on the following key domains: selection, performance, detection, attrition, and reporting bias. Most studies provided sufficient details regarding randomization procedures; however, the absence of clear allocation concealment in numerous trials increased the risk of selection bias. Detection bias remained a concern because many trials did not explicitly report whether the assessors were blinded during data collection. Attrition bias was evident in a few studies due to participant dropouts, but most addressed this issue by applying appropriate statistical methods, such as intention-to-treat analyses. Reporting bias was generally low, although selective emphasis on statistically significant outcomes was observed in a few trials. Furthermore, heterogeneity across studies was introduced by small sample sizes, variations in intervention protocols, and differences in the HRV measurement methods. Overall, several studies exhibited a moderate-to-high risk of bias, particularly in areas related to blinding and allocation concealment. Nevertheless, a subset of high-quality studies has employed rigorous methodologies, lending robustness to the overall findings. Despite these limitations, the evidence supports meaningful conclusions regarding the positive effects of yoga on HRV, particularly in individuals with chronic conditions. A summary table detailing the risk of bias across all the included studies is provided in the final manuscript [Figure 2].

4.DISCUSSION

This systematic review evaluated the impact of yoga on HRV across a range of physical, mental, and chronic health conditions, as well as in healthy individuals. These findings suggest that yoga interventions can enhance parasympathetic activity and promote autonomic balance, particularly in individuals with chronic conditions. However, the effects of yoga on HRV were less consistent in healthy populations and those with mental health conditions.

The results of our review partially align with those reported by Posadzki et al. and Tyagi et al., who highlighted the potential of yoga to influence HRV but emphasized the heterogeneity of findings and methodological limitations of early studies[16,17]. Posadzki et al. reported mixed results, noted a lack of conclusive evidence for yoga's efficacy in modulating HRV, and identified more positive trends in chronic conditions such as hypertension, diabetes, and rheumatoid arthritis. This may reflect improvements in methodological rigor in studies published in 2015. Tyagi et al. suggested that longer interventions and higher methodological quality were needed to establish robust conclusions. Our findings confirm this, with studies employing structured yoga programs for 12–16 weeks showing the most consistent improvements in HRV metrics, especially in populations with chronic conditions.

Studies examining the impact of yoga on chronic physical conditions, such as hypertension, type 2 diabetes, rheumatoid arthritis, and post-myocardial infarction, have consistently shown improvements in HRV metrics. Danasegaran et al. and Christa et al. reported increases in HF power and reductions in the LF/HF ratio, indicating enhanced parasympathetic activity and reduced sympathetic overactivity.[21,26] These changes are crucial for managing cardiovascular risk and metabolic dysfunction and support the integration of yoga into rehabilitation programs for chronic disease management.

Research on patients with mental health issues has shown mixed results regarding the effect of yoga on parasympathetic function. Gulati et al. and Lin et al. reported improvements, while Guthrie et al. found no significant changes in HRV.[27,30,31] These differences may stem from variations in intervention intensity, initial stress levels, or symptom severity. Despite inconsistent HRV findings, yoga consistently reduced depressive symptoms and stress, indicating that its benefits to mental health were not solely related to autonomic regulation.

The effects of yoga on HRV are limited to healthy individuals. Studies by Hewett et al. and Thrower et al. reported transient or minimal HRV changes, indicating that yoga may be more effective in patients with autonomic dysfunction or chronic stress. Similarly, research on acute stress responses by Chu et al. showed that single yoga sessions were insufficient to produce lasting improvements in HRV, emphasizing the need for long-term intervention.[34]

In cancer rehabilitation, Odynets et al. found significant improvements in HRV following a year-long yoga program in breast cancer patients.[37] The enhanced autonomic function and improved HRV metrics observed in this population highlight yoga's potential as a complementary

therapy to enhance the quality of life during recovery, further supporting its application in oncology care.

Limitations and Sources of Heterogeneity: Several limitations of the included studies contributed to the heterogeneity of the findings. A significant challenge arose from the variability in yoga practices, with studies employing different styles, such as Hatha, Vinyasa, Bikram yoga, and Bramhari pranayama. [23, 38-40] These variations in intensity, frequency, and duration make it difficult to draw generalised conclusions regarding the impact of yoga on HRV. Additionally, differences in HRV measurement protocols further complicate the comparisons across studies. Parameters such as the RMSSD, SDNN, and LF/HF ratios were used inconsistently, and measurements were obtained under varying conditions, such as at rest or post-intervention, contributing to mixed results.

The short duration of some interventions also limits their ability to detect meaningful changes in HRV. For example, Chu et al. involved relatively brief interventions, which may not have been sufficient to produce lasting autonomic changes. Small sample sizes in several trials further reduced statistical power, increasing the potential for type II errors and limiting the generalisability of the findings. Another limitation is the lack of blinding, which is often challenging in yoga research owing to the nature of the intervention. This introduces the risk of performance and detection biases, which potentially influence the outcomes reported in some studies. Collectively, these limitations highlight the need for more standardised methodologies, larger sample sizes, and longer interventions in future studies to better understand the effects of yoga on HRV.

Future Research Directions: Future research should focus on standardising yoga interventions by aligning the type, intensity, and duration of practice across studies to improve comparability and draw clearer conclusions regarding their effects on HRV. Additionally, longer intervention periods are needed to assess whether the benefits of yoga on autonomic function are sustainable over time. Research should also prioritise population-specific studies targeting individuals with autonomic dysfunction or chronic stress, as these groups are likely to experience the greatest impact from yoga interventions.

To deepen our understanding, future studies should explore the mechanisms through which yoga influences HRV, particularly the roles of breathwork and meditation components in modulating autonomic function. Incorporating advanced HRV metrics and measuring HRV under different conditions, such as during yoga sessions, could provide more nuanced insights into how these practices affect the autonomic nervous system. These directions will help address existing gaps and advance the evidence base for yoga use as a complementary intervention to improve HRV.

5.CONCLUSION

This systematic review emphasizes the potential of yoga to enhance autonomic function, as evidenced by improved heart rate variability (HRV), particularly among individuals with chronic conditions such as diabetes, hypertension, and rheumatoid arthritis. While the effects of yoga on HRV in healthy individuals and populations with mental health concerns exhibit less consistency, the associated benefits related to stress reduction and mental well-being indicate that yoga serves as a valuable complementary intervention. Nonetheless, the heterogeneity observed in study design and methodology highlights the necessity for further rigorous research to establish more definitive conclusions regarding the effects of yoga on HRV.

6.ACKNOWLEDGMENTS

None

7.AUTHOR CONTRIBUTIONS

All authors have reviewed and given their approval for the final version of the manuscript.

8.FUNDING

The authors affirm that no financial support has been received from any organization for the submitted work. Furthermore, all authors declare that they have no financial relationships with organizations that may have a vested interest in the submitted work.

9.ETHICAL STATEMENT

Ethical approval was not required for this study as it was a review article with data obtained through a literature search.

10.CONFLICT OF INTERESTS

The authors declare no potential conflicts of interest pertaining to the publication of this paper.

11.DATA AVAILABILITY

The data analyzed in this review were obtained from publicly available sources, including peer-reviewed articles, observational studies, and surveys, accessible through databases such as PubMed, Scopus, and Web of Science.

12.PUBLISHERS NOTE

This journal maintains impartiality concerning jurisdictional claims related
to published institutional affiliations.

REFERENCES

1. Shaffer F, McCraty R, Zerr C. A healthy heart is not a metronome: an integrative review of the heart's anatomy and heart rate variability. Front Psychol. 2014;4(1):46-61. doi:10.3389/fpsyg.2014.01040
2. Shaffer F, Ginsberg J. An overview of heart rate variability metrics and norms. Front Public Health. 2017;5(2):56-58. doi:10.3389/fpubh.2017.00258
3. Williams D, Cash C, Rankin C, Bernardi A, Koenig J, Thayer J. Resting heart rate variability predicts self-reported difficulties in emotion regulation: a focus on different facets of emotion regulation. Front Psychol. 2015;6(4):45-47. doi:10.3389/fpsyg.2015.00261
4. McCraty R, Shaffer F. Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. Glob Adv Health Med. 2015;4(1):46-61. doi:10.7453/gahmj.2014.073
5. Jandackova V, Scholes S, Britton A, Steptoe A. Are changes in heart rate variability in middle- aged and older people normative or caused by pathological conditions? findings from a large population- based longitudinal cohort study. J Am Heart Assoc. 2016;5(2):78-79. doi:10.1161/jaha.115.002365
6. Schiweck C, Piette D, Berckmans D, Claes S, Vrieze E. Heart rate and high frequency heart rate variability during stress as biomarkers for clinical depression: a systematic review. Psychol Med. 2018;49(2):200-211. doi:10.1017/s0033291718001988
7. Grässler B, Thielmann B, Böckelmann I, Hökelmann A. Effects of different training interventions on heart rate variability and cardiovascular health and risk factors in young and middle-aged adults: a systematic review. Front Physiol. 2021;12(6):200-202. doi:10.3389/fphys.2021.657274
8. Kloter E, Barrueto K, Klein SD, Scholkmann F, Wolf U. Heart Rate Variability as a prognostic factor for cancer survival - a systematic review. Front Physiol. 2018;9:623. doi:10.3389/fphys.2018.00623
9. Villafaina S, Fuentes-García J, León-Llamas J, Collado-Mateo D. Physical exercise improves heart-rate variability in obese children and adolescents: a systematic review. Sustainability. 2021;13(5):2946. doi:10.3390/su13052946
10. Sjoberg N, Brinkworth G, Wycherley T, Noakes M, Saint D. Moderate weight loss improves heart rate variability in overweight and obese adults with type 2 diabetes. J Appl Physiol. 2011;110(4):1060-4. https://doi.org/10.1152/japplphysiol.01329.2010
11. Brown L, Rando A, Eichel K, Dam N, Celano C, Huffman J, et al. The effects of mindfulness and meditation on vagally mediated heart rate variability: a meta-analysis. Psychosom Med. 2020;83(6):631-40. https://doi.org/10.1097/psy.0000000000000900
12. Basavaraddi IV. Yoga: Its origin, history and development. [Internet]. Delhi: Nanda Association; 2022 April [cited 2024 Oct 1]. Available from: https://yoga.ayush.gov.in/YAP/Yoga-History/Y-History.
13. Feuerstein G. The path of yoga: An essential guide to its principles and practices. 6th ed. Boulder (CO): Shambhala Publications; 2011. p. 22-5.
14. Chapman K, Bredin S. Why yoga? An introduction to philosophy, practice, and the role of yoga in health promotion and disease prevention. Health Fit J Can. 2011;3(2):54. https://doi.org/10.14288/hfjc.v3i2.54
15. Desikachar K, Bragdon L, Bossart C. The yoga of healing: exploring yoga's holistic model for health and well-being. Int J Yoga Ther. 2005;15(1):17-39. https://doi.org/10.17761/ijyt.15.1.p501l33535230737
16. Posadzki P, Kużdżał A, Lee M, Ernst E. Yoga for heart rate variability: a systematic review and meta-analysis of randomized clinical trials. Appl Psychophysiol Biofeedback. 2015;40(3):239-49. https://doi.org/10.1007/s10484-015-9291-z
17. Tyagi A, Cohen M. Yoga and heart rate variability: A comprehensive review of the literature. Int J Yoga. 2016 Jul;9(2):97-113. https://doi.org/10.4103/0973-6131.183712
18. Page M, McKenzie J, Bossuyt P, Boutron I, Hoffmann T, Mulrow C, et al. The
19. PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;17(6):45-50. https://doi.org/10.1136/bmj.n71
20. Sterne J, Savović J, Page M, Elbers R, Blencowe N, Boutron I, et al. ROB 2: A revised tool for assessing risk of bias in randomised trials. BMJ. 2019;l4(5):34-40. https://doi.org/10.1136/bmj.l4898
21. Kim H, Seo J, Song S. Effect of yoga on heart rate variability in women with metabolic syndrome. Korean J Health Promot. 2014;14(4):147. https://doi.org/10.15384/kjhp.2014.14.4.147
22. Danasegaran M, Pal G, Sahoo J, Pal P, Nanda N, Renugasundari M. Effects of 12 weeks practice of yoga on heart rate variability in males with type 2 diabetes receiving oral antidiabetic drugs: a randomized control trial. J Altern Complement Med. 2021;27(12):1105-1115. doi:10.1089/acm.2020.0489
23. Punita P, Trakroo M, Swaminathan R, Madhavan C. Heart
24. rate variability by Poincaré plot analysis in patients of essential hypertension and 12-week yoga therapy. Nat J Physiol Pharm Pharmacol. 2015;5(3):174-178. doi:10.5455/njppp.2015.5.1012201412

25. Balamadhuwanthi S, Latha R, Vedapriya D, Tamilselvan K, Mathangi D. Effect of chair yoga on heart rate variability, perceived stress, and sleep quality among nursing professionals from a tertiary care hospital. Biomedicine. 2023;43(01):499-503. doi:10.51248/.v43i01.2292
26. Patil S, Aithala M, Naregal G, Shanmukhe A, Chopade S. Effect of yoga on cardiac autonomic dysfunction and insulin resistance in non-diabetic offspring of type-2-diabetes parents: a randomized controlled study. Complement Ther Clin Pract. 2019;34:288-293. doi:10.1016/j.ctcp.2019.01.003
27. Archana R, Krishna A, Mukkadan J. Effect of om chanting and yoga nidra on depression, anxiety, stress, sleep quality and autonomic functions of hypertensive subjects – a randomized controlled trial. J Basic Clin Physiol Pharmacol. 2022;34(1):69-75. doi:10.1515/jbcpp-2022-0122
28. Christa E, Chandran D, Jaryal A, Yadav R, Roy A, Deepak K. Effect of yoga-based cardiac rehabilitation on heart rate variability: randomized controlled trial in patients post-MI. Int J Yoga Therapy. 2019;29(1):43-50. doi:10.17761/2019-00019
29. Guthrie K, Reed S, Landis C, Sternfeld B, LaCroix A, Dunn A, et al. A yoga and exercise randomized controlled trial for vasomotor symptoms: effects on heart rate variability. Complement Ther Med. 2016;26(53):66-71. doi:10.1016/j.ctim.2016.03.001
30. Telles S, Sharma S, Gupta R, Bhardwaj A, Balkrishna A. Heart rate variability in chronic low back pain patients randomized to yoga or standard care. BMC Complement Altern Med. 2016;16(1):45-50. doi:10.1186/s12906-016-1271-1
31. Ganesan S, Gaur G, Negi V, Sharma V, Pal G. Effect of yoga therapy on disease activity, inflammatory markers, and heart rate variability in patients with rheumatoid arthritis. J Altern Complement Med. 2020;26(6):501-507. doi:10.1089/acm.2019.0228
32. Gulati K, Bhargav P, Reddy P, Govindaraj R, Ravindran A, Gayathri D, et al. Adjunct yoga therapy: influence on heart rate variability in major depressive disorder - a randomized controlled trial. Asian J Psychiatry. 2021;65(8):102-103. doi:10.1016/j.ajp.2021.102832
33. Lin S, Huang C, Shiu S, Yeh S. Effects of yoga on stress, stress adaption, and heart rate variability among mental health professionals—a randomized controlled trial. Worldviews Evid Based Nurs. 2015;12(4):236-245. doi:10.1111/wvn.12097Chu I, Wu W, Lin I, Chang Y, Lin Y, Yang P. Effects of yoga on heart rate variability and depressive symptoms in women: a randomized controlled trial. J Altern Complement Med. 2017;23(4):310-316. doi:10.1089/acm.2016.0135
34. Dhargave P, Nalini A, Nagarathna R, Raju T, Sendhilkumar R, Adoor M, et al. Effect of yoga as an add-on therapy in the modulation of heart rate variability in children with Duchenne muscular dystrophy. Int J Yoga. 2019;12(1):55. doi:10.4103/ijoy.ijoy_12_18
35. Chu I, Lin Y, Wu W, Yu T, Lin I, Chang Y. The effects of acute yoga practice on heart rate and heart rate variability responses to mental stress. Int J Sport Exerc Psychol. 2022;21(4):660-672. doi:10.1080/1612197X.2022.2084762
36. Nagendra H, Kumar V, Mukherjee S. Cognitive behavior evaluation based on physiological parameters among young healthy subjects with yoga as intervention. Comput Math Methods Med. 2015;15(8):1-13. doi:10.1155/2015/821061
37. Lalitha S, Maheshkumar K, Shobana R, Deepika C. Immediate effect of kapalbhathi pranayama on short term heart rate variability (HRV) in healthy volunteers. J Complement Integr Med. 2020;18(1):155-158. doi:10.1515/jcim-2019-0331
38. Odynets T, Briskin Y, Тодорова В, Tyshchenko V, Бондаренко О. Effect of yoga in the modulation of heart rate variability in patients with breast cancer. Adv Rehabil. 2019;4(7):5-11. doi:10.5114/areh.2019.89821
39. Hewett Z, Pumpa K, Smith C, Fahey P, Cheema B. Effect of a 16-week Bikram yoga program on heart rate variability and associated cardiovascular disease risk factors in stressed and sedentary adults: a randomized controlled trial. BMC Complementary and Alternative Medicine. 2017;17(1):67-78. doi:10.1186/s12906-017-1740-1.
40. Thrower A, Barone Gibbs B, Alansare A, Sherman S, Davis K. Blood pressure and heart rate variability responses following an acute bout of vinyasa yoga and a prolonged seated control: a randomized crossover trial. PLOS ONE. 2023;18(11):94-95. doi:10.1371/journal.pone.0294945.
41. Maheshkumar K, Kamaldeen D, Pitani R, Amaldas J, Ramasamy P, Poonguzhali S, et al. Effects of yoga breathing practice on heart rate variability in healthy adolescents: a randomized controlled trial. Integrative Medicine Research. 2020;9(1):28-32. doi:10.1016/j.imr.2020.01.006.
42. Chu I, Lin Y, Wu W, Chang Y, Lin I. Effects of yoga on heart rate variability and mood in women: a randomized controlled trial. The Journal of Alternative and Complementary Medicine. 2015;21(12):789-795. doi:10.1089/acm.2015.0138.
43. Pakulanon S, Le Scanff C, Filaire E, Cottin F, Rama L, Teixeira A. Effects of yoga and mindfulness meditation on stress-related variables: a randomized controlled trial. International Journal of Yoga Therapy. 2024;34(8):729. doi:10.17761/2024-d-22-00021.

How to cite this article:
Giridharan, S., Ansari, J., & Pannerselvam, H. (2024). The impact of yoga on heart rate variability: A systematic review of randomized controlled trials. International Research Journal of Ayurveda and Yoga (IRJAY), 7(12), [online] 2024;7(12);30-41 Available from: https://irjay.com
DOI link- https://doi.org/10.48165/IRJAY.2024.71205

Figure 1

Summarized search strategy (Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram)

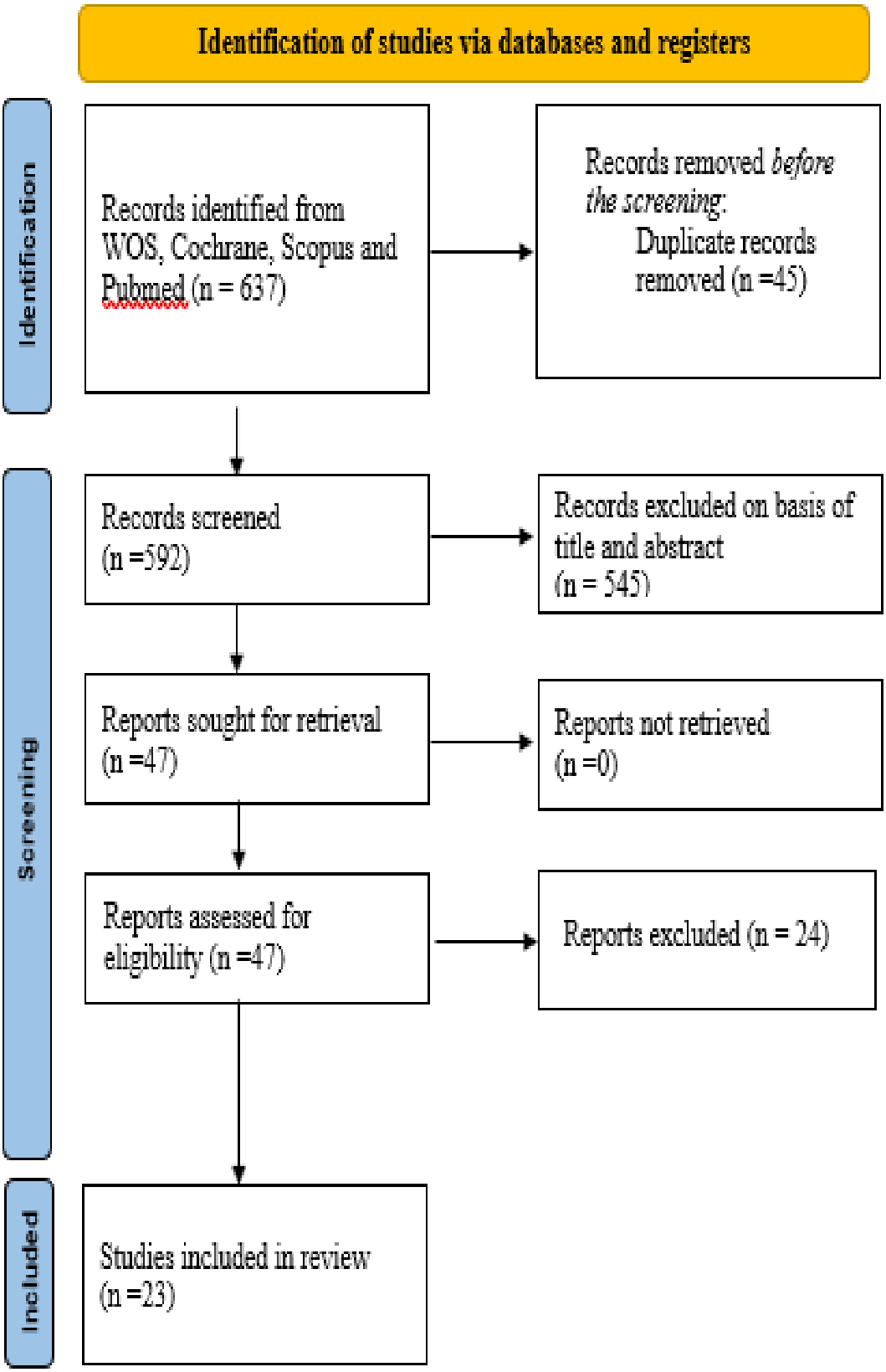

Figure 2 Risk of Bias Chart

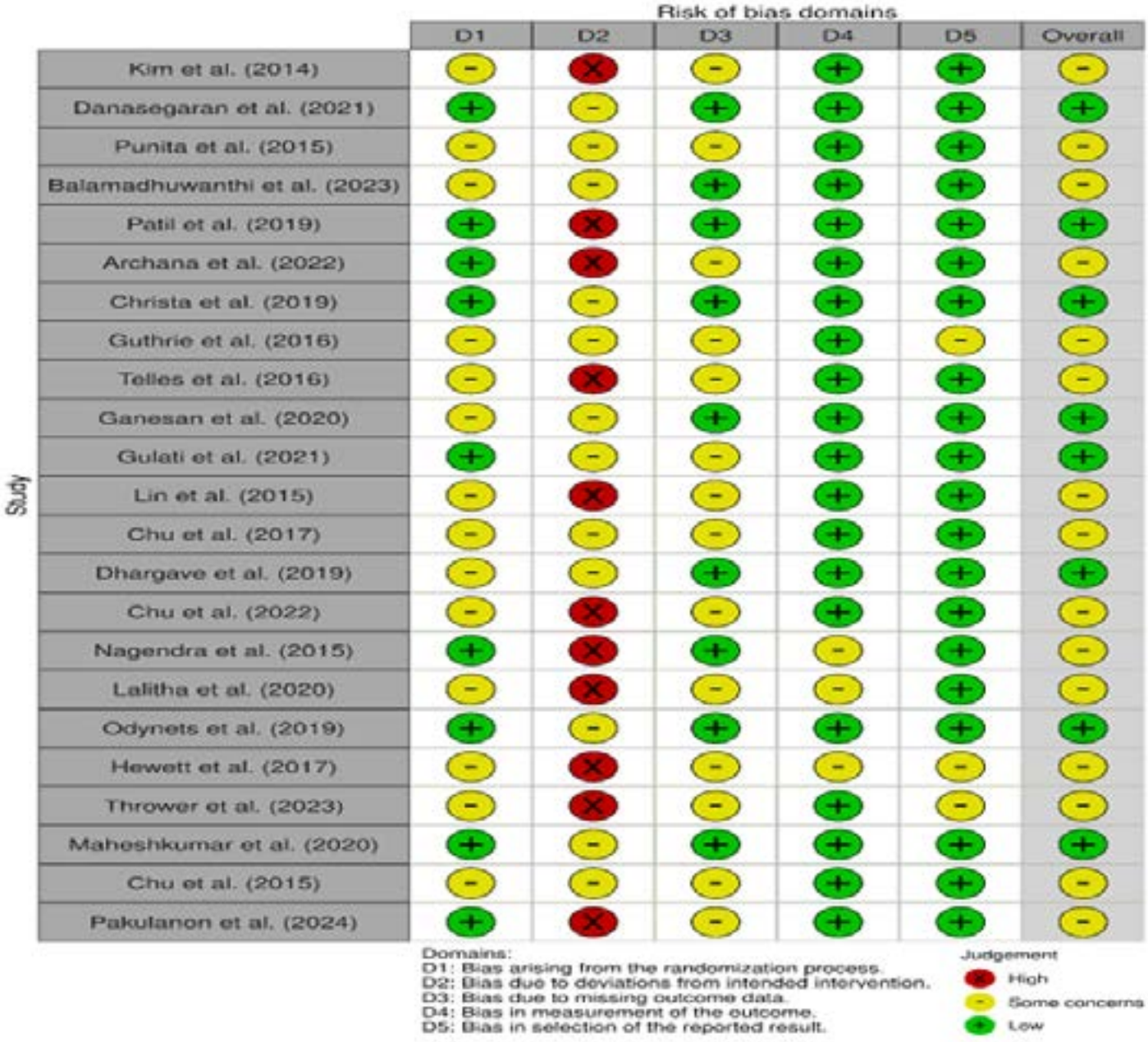

Table 1: Complete Summary of Study Characteristics and Main findings

Study	Population	Intervention	HRV Outcomes	Setting	Key Findings
Kim et al. (2014)[20]	39 post-menopausal women with metabolic syndrome	12-week yoga program	Reduction in LF power, no change in time-domain measures	Tertiary care hospital	Yoga reduced sympathetic activity, improving autonomic regulation.
Danasegaran et al. (2021)[21]	80 males with type 2 diabetes receiving oral antidiabetic drugs (OAD)	12-week structured yoga therapy including asana and pranayama	Increased TP, decreased LF/HF ratio	Outpatient clinic	Yoga improved sympathovagal balance and reduced cardiometabolic risks.
Punita et al. (2015) [22]	70 patients with essential hypertension	12-week supervised yoga therapy alongside medical care	Improved SD1 and SD2 from Poincaré plot analysis	Tertiary care hospital	Yoga reduced blood pressure and improved HRV using Poincaré plot analysis.
Balamadhuwanthi et al. (2023)[23]	60 nursing professionals	2-month chair yoga, 20 min/ day, 5 days/ week	Increased SDNN, PNN50, TP, HFnu, reduced LFnu and LF/HF ratio	Tertiary care hospital	Chair yoga reduced stress, improved sleep quality, and enhanced parasympathetic function.
Patil et al. (2019)[24]	Non-diabetic offspring of parents with type 2 diabetes	8 weeks of yoga training	↑ HF, ↓ LF/HF ratio, improved insulin sensitivity	Community-based	Yoga mitigated diabetes risk factors and improved HRV
Archana et al. (2022)[25]	Individuals with hypertension	Om chanting and Yoga Nidra alongside conventional medication	↑ HRV, ↓ depression, anxiety, stress, improved sleep quality	Tertiary care hospital	Effective complementary therapy for hypertension
Christa et al. (2019) [26]	80 patients recovering from myocardial infarction (MI)	12-week yoga-based cardiac rehabilitation program	Increased HF power and total power	Tertiary care hospital	Yoga shifted balance towards parasympathetic dominance, complementing cardiac rehabilitation.
Guthrie et al. (2016)[27]	335 peri- and post-menopausal women with vasomotor symptoms	12-week yoga program tailored for mid-life women	No significant changes in HRV across groups	Three clinical study sites	No HRV improvements; yoga likely benefits health through other mechanisms.

Telles et al. (2016) [28]	62 patients with chronic low back pain, aged 20–45	3-month yoga program	Decreased LF power, increased HF power and pNN50	Tertiary care hospital	Yoga enhanced parasympathetic dominance and reduced sympathetic overactivity.
Ganesan et al. (2020)[29]	166 patients with rheumatoid arthritis	12-week yoga therapy with standard medical treatment	Increased HF power, reduced LF/HF ratio, improved inflammatory markers	Tertiary care hospital	Yoga reduced disease activity and improved autonomic balance.
Gulati et al. (2021) [30]	68 patients with major depressive disorder	12-week adjunct yoga therapy	Decreased LF/HF ratio, no change in other HRV measures	Outpatient Psychiatric clinic	Yoga decreased LF/HF ratio, indicating enhanced parasympathetic function.
Lin et al. (2015)[31]	Mental health professionals experiencing work-related stress	12-week yoga program	Increased autonomic nerve activity, decreased work-related stress	Clinical settings for mental health professionals	Yoga reduced work-related stress and improved autonomic function.
Chu et al. (2017)[32]	26 sedentary women with elevated depressive symptoms	12-week yoga program with 60-min sessions twice weekly	Increased HF power, decreased LF/HF ratio	Community-based setting	Yoga increased parasympathetic tone and reduced depressive symptoms.
Dhargave et al. (2019)[33]	124 children with Duchenne muscular dystrophy	Physiotherapy (PT) with yoga vs. PT alone for 12 months	Improved HFnu with stable parameters for 12 months	Home-based physiotherapy and yoga program	PT and yoga improved cardiac function, but with similar outcomes to PT alone.
Chu et al. (2022)[34]	44 healthy adults, mean age 24.6	Single yoga session in a crossover design	No significant difference in HRV responses compared to control	Exercise psychology lab, counterbalanced design	Single yoga session did not outperform sitting in reducing HRV reactivity to stress.
Nagendra et al. (2015)[35]	Engineering students (healthy young individuals)	Daily yoga practice for 1.5 hours, 6 days a week, over 5 months	↑ SDNN/RMSSD, ↓ LF/HF ratio, improved cognitive performance	University campus	Yoga improved both HRV and cognitive performance
Lalitha et al. (2020) [36]	Healthy volunteers	Kapalbhati pranayama intervention	Temporary ↓ parasympathetic activity, recovery towards parasympathetic dominance	University setting	Kapalbhati shifts autonomic function temporarily but boosts recovery

Odynets et al. (2019)[37]	84 patients with breast cancer	Yoga exercise program within outpatient rehabilitation, 12 months	Increased SDNN, RMSSD, HF power, and TP	Outpatient rehabilitation program	Yoga enhanced parasympathetic function and reduced sympathetic dominance.
Hewett et al. (2017) [38]	63 stressed and sedentary adults	16-week Bikram yoga program	No significant change in HF power or other HRV parameters	Bikram yoga studios	No improvement in HRV, but higher adherence reduced blood pressure and body fat.
Thrower et al. (2023)[39]	18 healthy adults	60-minute vinyasa yoga session	Worsened HRV metrics post-session, despite favorable blood pressure responses	Physical Activity and Weight Management Lab, Pittsburgh, PA	Vinyasa yoga improved blood pressure but negatively impacted HRV post-session.
Maheshkumar et al. (2020)[40]	520 healthy adolescents	6-month Bhramari pranayama practice	Improved time and frequency domain parameters, shift to parasympathetic dominance	Community-based setting	Yoga breathing practice improved autonomic regulation in adolescents.
Chu et al. (2015)[41]	52 healthy women	8-week yoga program, 60-min sessions twice weekly	No significant change in HRV, reduced state anxiety	Community-based setting	Yoga reduced state anxiety but did not improve HRV.
Pakulanon et al. (2024)[42]	Healthy individuals	8-week yoga and mindfulness program, 45-min sessions, 3 times a week	↓ LF, ↑ HF, improved autonomic regulation	Community-based setting	Yoga enhanced autonomic regulation; mindfulness improved focus

Abbreviations: **HRV**: Heart Rate Variability, **LF**: Low Frequency, **HF**: High Frequency, **LF/HF** ratio: Ratio of Low Frequency to High Frequency, **TP**: Total Power, **SDNN**: Standard Deviation of the Normal-to-Normal Intervals, **RMSSD**: Root Mean Square of Successive Differences, **pNN50**: Percentage of Successive RR Intervals that Differ by More than 50 ms, **HFnu:** High Frequency Power (Normalized Units), **LFnu:** Low Frequency Power (Normalized Units)