Effect of Various Lengths of Respiration on Heart Rate Variability during Simple Bhramari (Humming)

Abstract

Background: Heart rate varies during breathing and the heart rate variability (HRV) facilitates the autonomic homeostatic capacity. The maximum HRV was observed at around 10 s of prolonged respiration as per HRV biofeedback literature. However, there is a gap in understanding the variations in HRV by different respiration lengths during simple Bhramari practice. **Objective:** To assess the effect of various respiration lengths (8, 10, 12, and 14 s) on HRV during the simple Bhramari (humming) practice. **Methodology:** A total of 118 individuals (67 males, 51 females) signed up for the study based on convenience sampling at a wellness center. A randomized (simple permutation) within-subject crossover design with repeated measures was used to measure their HRV during the simple Bhramari practice. The results were analyzed with one-way ANOVA and paired samples *t*-test. **Results:** The results indicate that, unlike the 10 s of respiration during HRV biofeedback breathing, maximum HRV during humming happens between 12 and 14 s of long breathing. **Conclusions:** The unique findings of the study demonstrate the maximization of HRV between the respiration lengths of 12 and 14 s. Future work should explore expanding the research to a broader group of participants, including individuals with chronic conditions and other demographic variables and mantra chanting.

Keywords: *Heart rate variability, heart rate variability biofeedback, humming, length of respiration, simple bhramari, yoga*

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Introduction

Slow breathing through respiratory sinus arrhythmia (RSA) increases heart rate variability (HRV: peak-to-trough heart rate differences). HRV is maximum during slow breathing at resonance frequency, as documented in HRV biofeedback research.[1-3] The HRV biofeedback practice increases the acceleration and deceleration of heart rate across the breathing cycle to enhance the autonomic homeostatic capacity. The involvement of RSA enables respiration-driven changes in heart rate mediated by the vagus nerve, which integrates baroreceptor inputs with the brain and changes heart rate.[2]

HRV biofeedback protocol development is extensively documented in terms of methodology and benefits through several meta-analysis reviews.[3-7] At the same time, there are several variations in the design of the protocol, such as resonance frequency (or length of breath that optimizes HRV), length of practice for which the measurement is done, validation of the resonance frequency (since there are variations from time to time for the same individuals), to name a few.[8] Yogic practices involve several breathing practices (Pranayama), and the benefits are well documented.[9-11] However, there are limited studies to understand the impact of Pranayama on HRV during the practice.[10,12,13] Within Pranayama, Bhramari (humming) has additional advantages. For example, Bhramari (or humming) includes a relatively higher increase in nitric oxide levels, increases lung capacity, and improves cardiovascular parameters.[13] Humming (simple Bhramari), given its similarity with chanting, could provide most of the benefits of chanting practices and the potential positive influence of lower respiratory frequency respiration on cerebrospinal fluid (CSF) flow.[14-18] In other words, the Bhramari practice provides several benefits beyond HRV biofeedback.[19] Hence, the opportunity

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to integrate the HRV biofeedback protocol insights to enhance the outcomes during the Bhramari practice could have several advantages, and with that context, the study plan was established.[19-21]

Based on the literature review, there is a gap in understanding how to optimize respiration (inhale-to-exhale ratio) during simple Bhramari practice and whether it could help us maximize the HRV. A study highlighted the increase in HRV during simple Bhramari practice, even when done with a comfortable respiration rate, and the outcome respiratory frequency was <0.1 Hz, i. e., <6 breaths per min (BPM), whereas another study identified the potential benefits between about 4.5 and 6.5 BPM.[12,13]

This study explored the application of HRV biofeedback practices to humming to understand if the benefits of HRV biofeedback resonant frequency (RF) can be extended to identify the RF breathing length to maximize the HRV during humming. The objective is to evaluate whether the RF of breathing further enhances the heart oscillations during the humming (simple Bhramari) practice. As per the literature review, this has not been explored, and there are limited studies on what happens to HRV during Bhramari practice.

Heart rate variability biofeedback research and the potential for reapplication

While there is an opportunity to integrate HRV biofeedback ideas into yogic breathing, specifically simple Bhramari, it is uncertain whether the same resonance frequency (0.1 Hz) from HRV biofeedback would work in the case of humming. The literature review has highlighted several opportunities to encourage the design of this study for the development of the protocol for simple Bhramari. Several obvious physiology-related changes warrant the pursuit of research beyond the benefits of humming highlighted earlier, including the recent insights linking low-frequency respiratory waves' positive impact on CSF flow.[18,22] The evidence provides several areas to seek further clarity on the gaps. For example, the Chanting and Bhramari also usually involve longer exhalation. At the same time, longer exhalation for yoga novice subjects does not provide better results compared to 5 s of inhalation followed by 5 s of exhalation![23] However, during humming (as compared to slow breathing), the nitric oxide level is significantly higher, and this usually involves longer exhalation.[16,24] At the same time, as captured earlier, there are several advantages of both techniques (HRV Biofeedback and Bhramari) and hence, the idea to explore if we combine the insights and set up a protocol that could provide better outcomes in HRV during the practice.

Review of existing evidence indicated the opportunity to identify optimum respiration length during the Bhramari practice. The range (in BPM: Breaths Per Minute) varies from (a) 3,[25–27] or (b) or 4 to 6,[28] or (c) only exhapation length specified (5 seconds),[29,30] and (d) no length specified[31,32] (for example,[31,32] did not specify a length for "Om" chanting,[33,34] referred to "Vedic" chanting only,[35] did not specific anything for the Gayatri Mantra,[36] did not specify details for "Vitthal" chanting, and[37] for Mind Sound Resonance Technique). This led to the identification of the range for the respiration from 8 to 14 seconds for this research as highlighted in Table 1.[2,3,15,38-40]

To summarize, no research has explored the linkage between respiration length in humming/chanting and HRV, and at the same time, in HRV biofeedback, there are several studies to validate the 0.1 Hz frequency (or 10 seconds long respiration, or resonant breathing).

Together with the unique benefits of increased nitric oxide during humming and the role of humming as as stress-buster, and the literature review on (a) HRV Biofeedback, and (b) the inconsistency of respiration length in Bhramari research provided multiple reasons to believe that the HRV outcome during humming (simple Bhramari) could optimize around a specific respiration length.[13,17,20,29] The following sections cover the study that explored the

Table 1: Resonance frequency estimation and respiration length

Respiration Rate (BPM) (Breaths/min)	Length of breath (seconds)	Peak Frequency (Hz)	Notes
4	15	0.07	
4.25	14	0.07	The outer limit of this research
4.5	13	0.08	4.5 to 6.5 BPM 4.5 to 7.5 BPM
5	12	0.08	
5.5	11	0.09	
6	10	0.10	
6.5	9.2	0.11	4.5 to 6.5 BPM
7	8.6	0.12	
7.5	8.0	0.13	4.5 to 7.5 BPM The outer limit of this research
8	7.5	0.07	
8.5	7.1	0.14	

BPM: Breaths Per Minute

identification of respiration length to maximize the HRV during humming (simple Bhramari).

Objective and hypothesis

The objective of this study was to assess the effect of various respiration lengths on HRV during the simple Bhramari (humming) practice and understand if there are variations by gender and age group.

The hypotheses are captured below:
1. The optimum breathing length is 12 s (4 s inhalation, 8 s exhalation) which causes the maximum HRV
2. The optimum length varies for (a) gender and (b) different age groups: subjects >40 years of age compared to younger subjects (provided we have balanced samples in each sub-group).

Methodology

Study design and participants

The study was a randomized (simple permutation) within-subject crossover design with repeated measures [Details in Figure 1]. The study is based on the institutional ethics committee approval (Ref No ECR/274/Inst/GJ/2013/RR-19, dated 27/10/2020). It is also registered with the Clinical Trials Registry, India (Registration No: CTRI/2020/12/029968). Informed consent was obtained from all subjects as per protocol before the enrolment in the study.

Study participants

Inclusion criteria

- Men and women aged between 18 and 70 years old, healthy individuals or with chronic diseases such as hypertension and diabetes, which are under control.

Exclusion criteria

- Individuals with disease complications (e.g., heart attack or stroke history or diabetes complications such as neuropathy or pacemaker, chronic pulmonary obstructive disease complications)
- Any recent surgery or procedure especially related to the ear, nose, and throat.

Study procedure

This experiment was conducted in an air-conditioned, quiet room with a temperature maintained at 25°C. Participants were requested to confirm they had no meal and coffee/tea at least 3 h before the practice.

Figure 1 shows the protocol used for the study, with participants randomly assigned to each of the four activities one after the other, with 2 min gap between the practices.

Humming (simple bhramari) practice

Several considerations related to the RF, length of inhalation and exhalation, and the cooling time (waiting period before the next activity) are highlighted below:

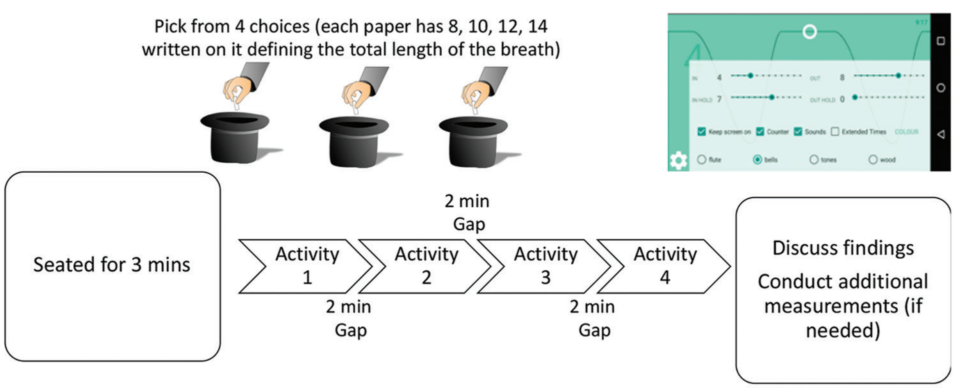

Figure 1: Simple bhramari protocol methodology

Methodology	Desired outcome
Seated for 3 min	Identify optimum BL to maximize the achievement and coherence data
Randomize readings (each 90 s long) at 8, 10, 12, and 14 s	
Inhalation and exhalation would be 3+5 for 8 s, 4+6 for 10 s, 4+8 for 12 s and 5+9 for 14 s to be managed with the Android App Breathe by Jatra or its video	Measures: Achievement, coherence and HR
There is a gap of 2 min between the readings	
Device: Emwave Pro PPG Device for R-R interval	
Analysis: Using Emwave Pro Software Data	
Subjects were guided for optimum length using the Android application Jatra for consistency	

BL: Breathing length, HR: Heart rate

The frequency range recommended from HRV biofeedback evidence is 4.5–6.5 or 7 BPM.[2,41] However, the chanting and Bhramari research indicated a range of 3 BPM (20 s long) to 6 BPM (10 s). For the study, the objective was to keep the process simple and, at the same time, be mindful that the humming process needs longer exhalation, so the inhalation needs to be within the RSA resonance frequency (i.e., max 5 s; hence, the range was established as 3–5, with 1-s interval). Exhalation was expanded to include a minimum of 5 s, and the maximum was extended to 9 s. Hence, 2-s interval gaps were identified, and the range of respiration frequencies was identified as between 8 and 14 s [Table 1]. Based on the insights from the study, future work can expand this range and explore shorter gaps between each respiration length. Additional evidence supporting the use of a 2-s interval is the research that RF or RF + 1 has a similar impact on sympathetic function and baroreflex.[42]

To summarize, (a) the additional 2-s length was added to the range of 8–12 s on either side of the established 10 s for this master experiment, considering the involvement of humming and the Bhramari data based on existing evidence, and (b) 2-s gap between each activity duration was derived at the existing research that 1 s may not make a meaningful difference, and the idea behind the protocol is to get a range and not specific RF across age group, gender and so on, and (c) the duration of 90s measurement was decided to simplify the process and maximize the sample size. The other alternative, i.e., a shorter cooling time of 90 s and a longer practice time of 120 s was not pursued to provide recommended and sufficient cooling time. As highlighted earlier, the literature review [Table 1] covers all the evidence that led to the range of respiration length (BPM).

Earlier experiments on breathing or humming-related protocols have used a few minutes of washout and a few minutes of the gap between the various practices. For this experiment, the proposed gap between various activities of 2 min is consistent with similar work in the HRV biofeedback area.[39,43-45] The practice duration of 90 s is based on the outcome (high variations in heart rate) that provides clean signals (ultra-short-term measures for Standard Deviation of Normal-to-Normal interval [SDNN] could be as low as 60s.[41]

Sample size calculations

Comparing the SDNN data based on 25 sample pilots, the means for 10s and 12s breath was 67.9 and 79.1, respectively, with SD of 17.7 and 25. Applying the power of 0.8 and the confidence interval of 0.95 yielded a sample size of 59 for each group. Given the randomized within crossover design, this makes the total 118, and a few additional samples are added for incorporating outliers or data inconsistency to make it 125 to ensure that we at least get 118 samples for analysis. Based on the availability of the subjects, there is an opportunity to break down the data for gender, age band (e.g., below and above 40), and healthy individuals versus individuals with chronic disease.

Data analysis and measurement

HRV was measured using an Emwave Pro device (Heartmath, Incl.) with an infrared pulse plethysmograph ear (or optional finger) sensor to measure beat-to-beat intervals. The data were exported using a. txt file from the Emwave Pro software for further analysis with Kubios Premium HRV software. The output of the processed HRV data from Kubios was imported back to Microsoft Excel for further analysis (ANOVA followed by paired samples *t*-test).

Several time-domain (SDNN interval, Root mean square of successive differences between normal heartbeats [RMSSD] between adjacent R to R intervals, Mean Stress Index, and total power) were measured. Frequency-domain parameters (low frequency [LF] normalized power or LF nu and high frequency [HF] normalized power or LF nu) were also measured consistent with the European task force recommendation and similar studies.[12,13,25,28,46] For further understanding, the reader is encouraged to explore the reviews providing insights on the measurement and watch-outs related to HRV.[41,47]

Results

We recruited 135 participants; 17 of them were excluded because of an error in the RR interval signal received from the device. A total of 118 participants, including 67 men and 51 women, completed the study [Table 2]. Seventy-one (60.2%) out of the 118 participants were in the age <40 years, and only about 21 (17.8%) of participants had physiological disease conditions.

Breathing length of 12 and 14 s significantly increases HRV.

Each parameter data had a normal distribution (based on the Kolmogorov–Smirnov Test of Normality). The normally distributed data were analyzed through Repeated one-way ANOVA followed by paired samples *t*-test. The normality test was conducted using the online tool, the ANOVA, and the paired samples *t*-test was performed using the Microsoft Excel data analysis tool pack.

Repeated one-way ANOVA measures showed statistically significant differences between breathing patterns for several time-and frequency-domain parameters in Table 3 (The table on the top shows key time-domain HRV parameters, and the table on the bottom shows key frequency-domain parameters). It was followed up with a paired samples *t*-test to understand the statistical significance of each parameter at different breathing lengths.

Based on the analysis, there were several findings: (1) The SDNN value was the highest for 14 s, followed by 12 s long breath. Both 14-s and 12-s breath's SDNN value was statistically significant compared to 8-s and 10-s-long breath. However, the SDNN value between 12-s and 14-s breaths was not statistically significant. (2) The Total Power value was the highest for 14 s, followed by 12 s long breath. Both 14-s and 12-s breath's total power value was better than 8-s and 10-s-long breaths. However, the total power value between 12-s and 14-s breaths was not statistically significant; (3) Stress index was lowest for both 12-s and 14-s breaths and each of these values was statistically significant compared to 8-s and 10-s breaths, respectively; (4) Mean RMSSD value was highest for 12-s breath, but the value was not statistically significant compared to each of the other breathing length (i.e., 8, 10 and 14 s); (5) For frequency domain parameters, all three critical parameters measured, i.e., LF/HF ratio, LF nu, and HF nu were ideal for 12-s and 14-s long breath. Specifically, LF nu was highest for 14-s breaths, and this value was statistically significant compared to 8-s, 10-s and 12-s-long breaths. Similarly, HF nu was the least for 14 s, which was statistically significant in the difference with other breathing lengths. Finally, the LF/HF ratio, consistent with the insights from LF nu and HF nu data, was the highest (statistically significant) for 14 s compared to other breathing lengths (8, 10, and 12 s, respectively).

The highest and the most statistically significant value for SDNN and Total Power are for 14s long breaths, even when compared to all other breathing lengths. This indicates that the coherence is the highest for 14 s long breaths ($P < 0.05$ for 14 s as compared to 12 s). The stress index was statistically significant for 12-s and 14-s breaths compared to all other breathing lengths ($P < 0.05$). For RMSSD, while the absolute value is highest for 12s, it is not statistically significant compared to all other breathing lengths. Therefore, most (but not all) of the time domain parameters indicate that 14 s long breath maximizes the HRV signals and not 12 s as hypothesized.

Table 2: Demographics for simple Bhramari and coherent breathing study

Characteristics	*n* (%)
Total	118
Age (years), mean±SD	38.47±12.53
Sex	
Male	67 (56.78)
Female	51 (43.22)
Health status	
Healthy	97 (82.20)
Hypertension	4 (3.39)
Type 2 or type 1 diabetes mellitus	14 (11.86)
Hormone issues (hyperthyroidism)	3 (2.54)

SD: Standard deviation

For frequency domain parameters, the LF/HF ratio is highest for 14 s long breaths, with a statistically significant increase during 14 s long breaths compared to all other breathing lengths, including 12 s breaths. For LF nu, the value is highest for 14 s with a statistically significant difference compared to 8 s, 10s and 12 s breath. HF nu data is very similar as well. The one-way ANOVA and unpaired *t*-test results' highlights are captured in Table 4.

The data indicate that the hypothesis is not true, i.e., 12s is not the optimum length. However, the results suggest that 14 s or 12 s are both acceptable and better compared to 10 s long breath. The following sections review a further breakdown of results by gender and age group.

Given the lack of balanced gender distribution in the existing data, this analysis is inconclusive. The recommendation is to take this up as future work with a specific focus on targeting the individuals (gender = female, age band ≥40, and with chronic conditions).

Discussion

This experiment evaluated the impact of breathing length (8-10-12-14 s long breathing length) on HRV during simple Bhramari (humming) practice. Based on the experimental design, several time and frequency domain HRV parameters were measured, followed by repeated ANOVA and paired samples *t*-test analysis to understand if the specific breathing length maximized the HRV parameters. The hypothesis that 12 s long breathing length maximizes the HRV parameter was not correct. Instead, the results indicate that both 12-s and 14-s-long breathing

Table 3: Heart rate variability parameters during humming at different breathing lengths

BL (s)	Mean HR	Mean SDNN	Mean RMSSD	Mean stress index	Mean total power
8	83.12±10.41	52.63±22.02	44.26±16.88	11.64±4.42	2885.96±2604.32
10	83.21±10.50	60.38±23.42	43.86±16.57	10.49±3.98	3870.96±3059.31
12	82.77±10.28	67.36±24.86	44.62±14.99	9.48±3.33	4900.32±3746.62
14	82.66±10.20	69.31±27.07	43.09±14.96	9.48±3.58	5616.51±4576.34

BL (s)	Average of LF nu	Average of HF nu	Mean LF/HF ratio
8	78.25±12.91	19.33±11.34	6.31±4.99
10	79.90±13.10	18.31±12.33	7.20±5.98
12	81.27±12.68	17.37±11.67	8.46±8.97
14	86.08±11.97	14.37±14.41	11.70±11.60

LF: Low frequency, HF: High frequency, SDNN: Standard deviation of normal-to-normal, RMSSD: Root mean square of successive differences, HR: Heart rate, BL: Breathing length

Table 4: Heart rate variability parameters and statistical significance with breathing length

HRV parameter	14 s	12 s
SDNN	Preferred	
Stress Index	Preferred	
Total Power	Preferred	
RMSSD	Not significant	Highest but not significant
LF nu, HF nu and LF/HF ratio	Ideal	Next preference

HRV: Heart rate variability, LF: Low frequency, HF: High frequency, SDNN: Standard deviation of normal-to-normal, RMSSD: Root mean square of successive differences

lengths effectively increase several HRV parameters compared to 8-s or 10-s-long breaths. Several interesting insights from the results are captured below.

First, the time domain parameter SDNN – denoting the coherence or the variations between subsequent heartbeats – increases for 12-s and 14-s-long breaths. This finding is unique since all the HRV biofeedback research (focused only on breathing and not humming) indicated the HRV to peak at around 10-s-long breath. The evidence in chanting also indicates that the HRV is generally maximum at 10 s long breath or the breathing frequency of 0.1 Hz.[1,3,5,14,15,48] Reviews of humming or Bhramari also have not provided any additional insight on the resonance frequency for humming/Bhramari and Chanting, with variations in breathing length for a few Bhramari research.[12,19] Our review also indicated that variations for slow breathing in the inhale–exhale ratio also do not provide any unique additional benefits. Given the prior evidence and the unequivocal support at or around 0.1 Hz breathing frequency, the findings from this experiment, coupled with the earlier experiment comparing breathing and humming, provide new evidence that increasing the breathing length with longer exhalation (while creating sound vibrations) can be even more effective compared to just slow breathing or HRV biofeedback-based respiration process. Second, several time and frequency domain parameters support the basis for 12 s and 14-s breathing during the practice, especially the total power and stress index. Unlike HRV biofeedback, which suggests 10 s of long respiration, yogic studies have explored the use of 12 s of breath consistent with our approach that uses a much broader range (8–14 s) for the study.[49,50] Third, the increased total power and the higher concentration of that power in the LF band (LF nu) confirm the assumption that humming at 12 and 14 s generates strong HRV oscillations. An increase in the LF band and, therefore, a higher LF/HF ratio during the practice is consistent with the earlier findings during Bhramari practice (at six BPM) as well as slow breathing (alternate nostrils breathing).[12,51] It indicates the mechanism of action that concentrates power in the LF band observed at both 12 and 14 s in our study. Finally, the increased HRV, increased nitric oxide (as per earlier evidence), and the potential impact of slow breathing and vibrations on the brain (such as increased cortical thickness as demonstrated during chanting or the positive impact on CSF circulations) and cognitive function (through several chanting studies) provide a new perspective about the "mechanism of action."

There are several limitations of the study. First, the sample size for sub-groups (gender, age group) was not balanced; hence, while that data were available, it was not analyzed, and hence, no conclusion can be made about the sub-groups. Future work should explore stratified random or quota sampling and adjust for design effect to get insights. Second, the study took four different breathing lengths, each 2 s apart. While this provided clarity, there is an opportunity to refine the outcome to the nearest second further. Third, the study did not measure lung capacity or other parameters (such as peak exploratory flow). Future work can consider linking the lung capacity with the optimum breathing length and HRV.

Several elements in the results either provide new insight or create additional ideas for future research. First, the earlier studies[23,39] have validated that the inhale-to-exhale ratio (I: E ratio) involves the same inhalation, and the exhalation rate generates optimum (or maximum) HRV during HRV biofeedback. The results highlighting even more pronounced outcome in HRV parameters during the I: E ratio of 4:8 and 5:9 (compared to 3:5 and 4:6) provides new data on humming's ability to generate better HRV that can be further optimized by applying the protocol. Second, earlier research has used several variations in total breathing length [without specifying the I: E ratio, covered in Table 1]. The results of this experiment have demonstrated that when considering the range of 8-14 s long breath, the HRV peaks at both 12 and 14 s. The findings further substantiate that during humming, the increase in heart oscillation is far bigger compared to slow breathing, and even during breathing, at 12 s and 14 s, the HRV peaks for most individuals. Earlier research has demonstrated an increase in several HRV parameters (Total power, LF/HF ratio, SDNN, and RMSSD were the highest) during alternate nostril breathing.

Similarly, our study provides insights to maximize the HRV parameters during simple Bhramari.[13,51] Third, the findings from this study are different when compared to the limited chanting research highlighted earlier that noted 10-s-long respiration during various chanting methods.[14,15] Finally, all these points lead to a new and unique finding from this study: to achieve increased HRV, humming at specific lengths can be extremely effective even when compared to established HRV biofeedback research based on RF breathing at 10 s.

The above discussion highlights facts, presents the new findings of the results, and compares them with similar results to identify the uniqueness of the results. Several contributors to this increased HRV are linked to better health and well-being, and hence, they need additional discussion.[1,6,48,52] First, humming can generate unique outcomes such as significantly higher levels of exhaled nitric oxide versus "nasal" breathing (Slow nasal breathing generates more nitric oxide compared to mouth breathing). Since the earlier study validated humming's ability to generate even better HRV, the additional findings of the study provide validation that even for humming, there are potential lengths of breath (and I: E ratio) that can generate higher peaks in the heart's signals.[13] This is one more positive confirmation of the potential benefits that humming can provide. Second, the RF equivalent of 12 and 14 s is about 0.08 Hz and 0.07 Hz, respectively, much below the 0.01 Hz based on HRV biofeedback research. At these frequencies, there is a significant increase in cardiovascular oscillations and baroreflex sensitivity, indicating a dynamic interaction between respiratory and cardiovascular systems.[51] This component of 0.07–0.08 Hz is a respiratory component that profoundly impacts the CSF flow discussed earlier. While we cannot deduct the impact of humming on CSF flow from the current study, what is clear based on the study's results is that it is possible to lower the RF below 0.1 Hz. This lowering may further enhance the respiratory component's positive impact on the CSF flow. If and how this influences CSF flow, it could be part of the future study since humming also adds a component of "sound" vibrations to the respiratory frequency. Third, chanting research[32-34,36] has already established its impact on cognitive function and cortical thickness.

The findings also highlight several mechanisms of action. During the simple Bhramari practice (during 12–14 s long breath), there is a strong coupling between respiratory and cardiovascular systems demonstrated by the increase in several HRV parameters during the practice that matches the insights from earlier studies on slow breathing and Bhramari.[12,51] The increase in power during 12–14 s long breaths (i.e., respiratory frequency of 0.08-0.07 Hz) has been observed during slow breathing earlier.[51] While the frequency range is lower compared to HRV biofeedback (around 0.1 Hz), the findings indicate that during humming that employs longer exhalation, the benefits could be achieved at a lower frequency (or longer breaths) compared to HRV biofeedback. Long breaths (beyond 10 s) have been validated to increase HRV earlier, both during slow breathing and humming (with or without breath retention).[12,49,51] The sound vibrations (similar to repetitive chanting) during the practice could also provide additional benefits. Finally, the recent studies providing the correlation between respiration frequencies (below 0.1 Hz) and CSF flow through the component of slow breathing provide possibilities to explore the impact of both slow breathing and humming (or chanting) on the CSF flow.[13,22,53]

Conclusions

This experiment demonstrated the optimum breathing length to maximize the HRV during simple Bhramari (humming) between 12 s and 14 s. It is a unique finding since most earlier evidence indicates an optimum breathing length of only 10 s. The inability to get balanced samples limited the conclusion to only the breathing length and not the demographics – a limitation that future studies can address. Future work can also integrate the insights from this experiment to study how different breathing lengths influence the HRV during mantra chanting.

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Conflicts of interest

There are no conflicts of interest.

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