



Research Article

BHRAMARI PRANAYAMA - A UNIQUE VOICE CULTURING TECHNIQUE

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ABSTRACT

A good voice is the basic need of humans. For professional voice users, voice governs their livelihood and social attraction. A good singing voice is attained by the regular vocal exercises and vocal training. Singing involves the skills like respiration, phonation, resonance and articulation. *Bhramari Pranayama* (BP) involves both humming and respiration. Humming is the resultant of the activity vocal structures which may have effect on the quality of the voice. **Aim:** To evaluate the effect of *Bhramari Pranayama* (BP) on voice quality **Settings and Design:** The study is an open clinical trial involving 30 healthy prospective singers fulfilling the inclusion and exclusion criteria, consenting for the study, who were enrolled through a survey in music schools in the region of Belagavi, Karnataka. **Methods and Material:** The voice of the 30 healthy prospective singers was recorded using PRAAT software with standard vocal tasks on day 0 of the study. Participants practiced 21 cycles of *Bhramari Pranayama* in the morning for 30 days. On Day 30, after the practice the voice was re-recorded with same vocal tasks and standard operative procedures being maintained. The recorded voice samples were saved and were subjected for voice analysis using softwares PRAAT, Vagmi, CSL at AIISH, Mysuru. **Statistical analysis used:** Statistical analysis was done using SPSS 21 and Paired 't' test was applied to derive the results. Statistical Significance was set up at $p < 0.05$. **Results:** *Bhramari pranayama* showed highly significant results in the root mean square values of the Singing power ratio - SPR ($p < 0.01$) and singing power difference ($p < 0.01$). Significant results in the lowest value of the singing amplitude ($p < 0.05$), singing amplitude range ($p < 0.01$) and mean formant frequency of second formant of vowel /u/ ($p < 0.05$). **Conclusion:** *Bhramari Pranayama* improved the resonance characteristics of the voice and there by improved the quality of singing voice in prospective singers.

INTRODUCTION

Human voice is the faculty that renders Man a unique distinction amongst other living creatures. It reflects one's own personality, gender, age, emotions and other gestures. A good voice is the basic need of humans. For professional voice users like the vocalists,

actors, teachers, radio jockeys', news readers etc, the voice governs their livelihood and social attraction. Hence an effective voice is a goal worth pursuing.^[1] A beautiful voice depends on three interconnected imperatives like Vibration, closure and lubrication linked to the vocal cords.^[2]

Singing is defined as a sensory motor phenomenon that requires particular balanced physical skills such as respiration, phonation, resonance, and articulation. These skills are often developed as a result of training and singing experience, thereby creating a distinction in physiological, acoustic, and perceptual parameters of the voices of singers compared with that of non-

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singers.^[3,4] The process of singing needs voice modulation which involves training of vocal muscles, vocal cords and other structures and systems involved in the production of voice.^[4] It also needs a perfect co-ordination of brain and body.

Bhramari Pranayama (BP), is a humming type of *Pranayama*, has beneficial effects on the human physiology like pulmonary functions, cardio-vascular functions and cognitive function which are supported by clinical research.^[5,6,7,8] In the act of breathing, humming (one of the attribute of vocal music) is a phenomenon occurring due to the resonance of air in the passages of head, throat, and chest. Since *BP* regulates breathing and involves humming, it may have some changes on vocal cords and local structures. Hence the present study is an attempt to evaluate effect of *BP* as an intervention, on voice quality of singers if adopted as a vocal exercise.

MATERIALS AND METHODS

Study design: The study was conducted in the Department of Swasthavritta and Yoga of KAHER's Shri B. M. Kankanawadi Ayurveda Mahavidyalaya, PG Studies, KLE Ayurveda Hospital and Medical Research Centre, Belagavi and All India Institute of Speech and Hearing, Mysuru, Karnataka, India.

Microphone: The U1 USB Windows and Macintosh compatible Dynamic Recording Microphone, with desktop mic stand and mic clip was procured from CAD Professional Microphones, USA.

Software: PRAAT 5.3.53 (Boersma & Weenink), Vaghmi (Voice and Speech system, Bangalore) and Computerized speech Lab (CSL, 4600) by Kay Elemetrics, NJ were used at All India Institute of Speech and Hearing, Mysuru for the objective evaluation of voice quality.

Participants: 30 healthy prospective singers fulfilling the inclusion and exclusion criteria, having the basic knowledge of Indian vocal music and consenting for the study were enrolled through a survey in music schools and other educational institutes in the region of Belagavi.

Selection Criteria

Inclusion criteria

- Apparently healthy prospective singers irrespective of gender, religion and occupation.
- Age 18-35years.

Exclusion Criteria

- K/C/O respiratory and endocrine disorders.
- Hearing disorders.
- Acute and chronic vocal disorders.

Ethics and CTRI Registration: Ethical clearance was obtained from Institutional Ethics Committee for Human Research with the IEC number being BMK/15/PG/SV/22 and clinical trial was registered to

CTRI with registration number CTRI/2018/01/011218.

Intervention Protocol

Day 0	Day 1 - Day 30	Day 30
Recording of voice	Practice of 21 cycles <i>Bhramari Pranayama</i>	Re-recording of voice after practice

Methodology

On a telephonic and a personal consent obtained by the authorities of the music schools, an education of *Bhramari Pranayama*, its health benefits and aims of the present study imparted in the respective music schools. A note of volunteering subjects was made and they were invited to visit the KLE Ayurveda Hospital, Belagavi for the participation in the study. The volunteers were given the telephonic appointment for the voice recording priority. On their arrival, voice recording, the Patient Information Sheet (PIS) was given and the details of the study were explained to the participants, following which an Informed Consent (IC) was taken from the participants. The basic details of the participant needed for the study was procured as per the approved Case Record Form (CRF).

Voice Recording

The voice of the consented and the eligible participants was recorded in a silent, closed room. The entire procedure of voice recording accounted to 20-30 minutes in the pre-noon time. The participants were made to sit on a knee height chair. They were instructed to relax at the time of recording and were instructed to perform various vocal tasks which were standardised to record the voice sample as per participant's comfort and capacity. The tasks included:

- **Phonation of Vowel** (i.e., Prolonging the vowel utterance for more than 5 seconds continuously- three vowels /a/, /i/, /u/, each for three trials.
- **A Standard Passage Reading** in a language comfortable to the participants (Standardized English passage-Rainbow passage/Standardized Kannada passage-Bengaluru passage)
- **Singing Vandemataram song** with a standard tune.

The voice recording was done through a software named PRAAT-5.3.53 (Boersma & Weenink) and the microphone (being connected to the laptop), was kept 10-15cm away from the subject's mouth, at approximately 30 degree angle. The voice was recorded in a mono sound recording channel, at a sampling frequency of 44100 Hz and 16 bit rate. The same procedure of voice recording was followed on Day 0 and Day 30 of the study period. The recorded samples were saved in the **wav** format and used for analysis.

Practise of *Bhramari Prananyama*

On the day for the arrival for voice recording (day 0), the subjects were demonstrated the practice of *Bhramari Pranayama*. The subjects practiced 21 cycles of *Bhramari Pranayama* by attaining the *Shanmukhi mudra*^[9,10] (Fig 1) everyday for 30 days in a well ventilated and a clean environment.

The re-recording was done on the 30th day after the practice, with the same vocal tasks performed and by maintaining the same standard recording protocols as before

Analysis of Voice Samples

The voice samples were analysed by the objective acoustic parameters like Long term average spectrum (LTAS) and Singing power ratio (SPR) at All India Institute of Speech and Hearing, Mysuru using PRAAT 5.3.53 (Boersma & Weenink), Vaghmi (Voice and Speech system, Bangalore) and Computerized speech Lab (CSL, 4600) by Kay elemetrics, NJ.

Measurement of Singing Power Ratio (SPR): (Fig 2)

The recorded singing samples were transferred to the computer. Computerised Speech Lab (CSL 4500 model) from Kay PENTEX, New Jersey, and USA was used to estimate the SPR. The duration of the selected sample was 60-80 seconds. SPR was extracted from the Long term average spectrum (LTAS) using Hamming window. Energy peaks between 0-2kHz and 2-4kHz were measured and the RMS values between these intervals were also noted (Figure 01). The Singing power was calculated by two methods:

i. SPR Ratio method: The ratio was calculated by dividing the peak values and rms values from 2-4 kHz and 0-2 kHz.

SPR = peak value of 2-4 kHz/peak value of 0-2kHz

SPR= rms value of 2-4 kHz/rms value of 0-2kHz

ii. SPR Difference Method: The difference was calculated by subtracting the peak values and rms values from 2-4 and 0-2 Hz

SPR = (peak value of 2-4 kHz)-(peak value of 0-2 kHz)

SPR= (rms value of 2-4kHz)-(rms value of 0-2 kHz)

Measurement of LTAS: (Fig 3)

The recorded singing samples were down sampled to 16kHz, sampling rate to make it compatible with the Vaghmi software using the "Vaghmi Diagnostics" module. The Long Term Average Spectrum (LTAS) was estimated for each singing sample and the Alpha, Beta and Gamma values were measured for voice of each participant. The block duration was kept as 32 milli seconds for estimation of LTAS.

- Alpha value: Ratio of average energy between 0-1kHz/1-5kHz
- Beta value: Ratio of average energy between 0-2kHz/2-8kHz

- Gamma value: Ratio of average energy between 0-1kHz /5-8kHz.

Measurement of Fundamental Frequency, Frequency range, Amplitude Range and Formant Frequencies of Vowels

The samples recorded at 44 kHz and 16 bits were transferred to a computer and PRAAT software was used for the purpose of voice sample analysis.

a. Mean Fundamental Frequency

The phonation samples of vowel /a/, /i/ and /u/ recorded for 5 seconds was considered for analysis of mean fundamental frequency (mF0) for each vowel individually. Passage reading samples for 25 seconds were considered for measuring the mean speaking fundamental frequency (mspkF0). The mean speaking fundamental frequency of voice was noted from the voice report of the sample from PRAAT software.

b. Fundamental Frequency Range

The passage reading samples were considered for measuring the fundamental frequency range. The highest and the lowest value of the fundamental frequency for the sample were noted from the voice report and the range was calculated manually.

c. Amplitude Range

The singing samples (1minute 10s) were considered for measuring the Amplitude range. The highest and the lowest value of the intensity (amplitude) for the sample were noted from the voice report and the range was calculated manually.

d. Measurement of Formant Frequencies of vowel/a/, /i/, /u/

The phonation sample of each vowel was analysed in the PRAAT software. The second formant frequency (Ff F2) for each vowel for three trials was noted and the mean for each trial was manually calculated. The values were noted for the parameter as mean Formant frequency F2 /a/ (mFff2 /a/), mean Formant frequency F2/i/ (mFff2 /i/), mean Formant frequency F2/u/ (mFff2 /u/).

Analysis of the Results: The data was statistically analysed using the software SPSS version 21.

OBSERVATIONS

After the practice of 21 cycles of *Bhramari Pranayama* for 30 days 73.33%, 53.33%, 83.33% and 70% of subjects experienced improvement in the quality of sleep, attained vocal stability, vocal prolonging and pleasantness of voice respectively and 66.66% experienced reduction in the vocal strain.

20%, 3.33% and 3.33% subjects experienced mild headache, mild headache- heaviness and severe headache respectively after the practice.

RESULTS

- *Bhramari Pranayama* (BP) showed a highly significant (p<0.01) effect on Singing Power Ratio

(SPR rms) and Singing Power Difference (SPD rms) of voice samples (Table 01).

- BP showed a considerable effect on LTAS parameters and effect nearing to significance on beta value specifically (Table 02).
- BP showed highly significant effect on Singing Amplitude range (Sng-A0 range) ($p < 0.01$) and

Lowest value of Singing amplitude(Sng-A0 low) ($p < 0.01$) of the voice samples (Table 03).

- Non-significant effect was witnessed on mean formant frequencies (mFf) of vowels (Table 04), fundamental frequency (Ff) (Table 05) and fundamental frequency range (F0) (Table 06) of voice samples.

Table 1: Effect of the Intervention on SPR rms and SPD rms Parameters

Parameter	Day 0		Day 30		't' Value	'p' Value	Significance
	Mean	SD	Mean	SD			
SPR rms	0.345	0.112	0.399	0.113	-3.565	0.001**	Yes
SPD rms	-11.82	1.953	-11.06	1.683	-4.064	0.000**	Yes

* $p < 0.05$, ** $p < 0.01$

Table 2: Effect of the Intervention on Alpha, Beta and Gamma Values of LTAS

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Alpha	10.02	4.533	9.574	4.523	0.996	0.328	N
Beta	17.34	4.013	16.31	3.321	2.485	0.019	Y
Gamma	31.44	3.913	24.04	3.397	1.041	0.306	N

* $p < 0.05$, ** $p < 0.01$

Table 3: Effect of the intervention on Sng-A0 Low and Sng -A0 range

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Sng-A0 Low	40.92	3.139	39.28	3.044	2.916	0.007**	Yes
Sng -A0 range	39.84	4.146	42.47	4.013	-4.247	0.000**	Yes

Table 4: Effect of the intervention on Fundamental frequency (Ff) for F2 for /a/, /i/ and /u/

Parameter	Day 0		Day 30		't' value	'p' value	Significance
	Mean	SD	Mean	SD			
mFf For F2-/a/	1446.9	136.6	1425.4	156.6	0.816	0.421	N
mFf for F2-/i/	2789.4	296.8	2601.9	505.4	1.863	0.073	N
mFf for F2-/u/	942.7	131.5	1007.6	176.4	-2.176	0.052	N

Table 5: Effect of the intervention on Mean Fundamental Frequency (mF0) for /a/, /i/, /u/

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
mF0 for /a/	207.8	45.55	205.0	46.37	0.654	0.518	N
mF0 for /i/	213.2	50.15	217.7	47.80	-0.985	0.323	N
mF0 for /u/	220.7	48.34	222.0	48.82	-0.468	0.643	N

* $p < 0.05$, ** $p < 0.01$

Table 6: Effect of the intervention on Singing Frequency range (Sng F0 -range)

Parameter	Day 0		Day 30		't'	'p' Value	Significance
	Mean	SD	Mean	SD			
Sng -F0 range	287.6	81.66	273.0	68.19	1.268	0.215	N

FIGURES



Figure 01: BP with Shanmukhi mudra

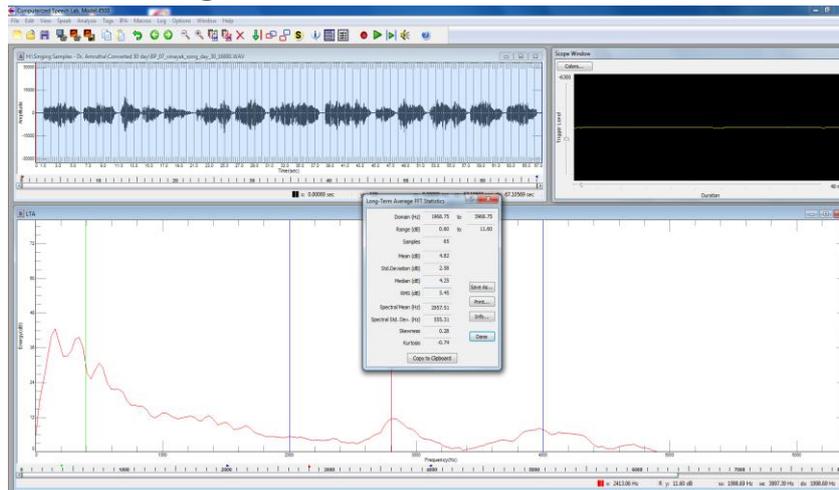


Figure 02: CSL window showing the Peak and RMS values of voice sample

Prepared using Vagmi Software of Voice and Speech Systems

Client's Name: aka, Age: 26, Gender: Female, Client's ID: 2351, Ref. By: Dr ABC, Ref. By: Unknown

Sample File Name: vinayak.WAV

F0 and Int Statistics	F0 in Hz		Int in dB		LTAS Statistics		dB	Ln
	Meas.	Norm.	Meas.	Norm.				
Mean	142.67	196.40	97.74	100.00	E1: Energy (0 to 1 kHz)	88.963	7.87	
Maximum	176.15	236.40	105.29	115.00	E2: Energy (1 to 5 kHz)	72.223	0.17	
Minimum	94.76	156.40	79.51	80.00	E3: Energy (0 to 2 kHz)	89.020	7.98	
Range	81.39	80.00	25.78	35.00	E4: Energy (2 to 8 kHz)	68.841	7.66E-02	
					E5: Energy (5 to 8 kHz)	61.450	1.40E-02	
					Total Energy	89.062	8.06	
					Alpha Ratio (E1/E2)	16.741	47.213	
					Beta Ratio (E3/E4)	20.179	104.212	
					Gamma Ratio (E1/E5)	27.513	563.987	

↓TAS Notes :

Figure 03: Vagmi diagnostics window showing the final LTAS results of voice sample

DISCUSSION

SPR is an objective measure which can quantify the resonant characteristics of vocal tract, indicate the acoustic characteristics and quality of resonant tuning in the vocal tract of a singing voice through the spectrum analysis. It shows a distinctive relationship with period of voice training.^[13,14,15] In the present study, the Paired 't' test, has shown a highly significant improvement in the root mean square value (rms) of Singing Power Ratio (SPRrms and SPD rms) BP involves a constant humming at the phase of exhalation, which might bring the resonance effect in

the oral cavity and nasal cavity. Humming has a potential to improve voice quality by stabilizing the vocal fold oscillation, remove the perceptual vocal roughness.^[12] The immediate effects of humming was shown to induce a long-term improvement on the perceptual vocal roughness, perturbation parameters, cause an increase in the contact quotient (CQ), a parameter reflecting the degree of vocal fold contact during phonation. ^[13,14,15,16]. The present study as well, a constant humming during the exhalation might have caused the tuning of the vocal tract resonance, which is

reflected by the significant improvement in the values of SPRms and SPDms.

Long Term Average Spectrum (LTAS) is a valuable tool for analysing running speech and singing and reveals the overall voice spectral characteristics. The LTAS contour reflects contributions from the voice source and the resonance or formant characteristics of the voice.^[17] The Paired 't' test has shown improvement nearing to significance for the beta values of the LTAS. In the present study, similar to the SPR, beta value LTAS also represent the improvement in the resonant quality of the voice. Many studies establish that similar to SPR, LTAS is an effective tool to measure the voice quality.^[18,19]

Highest and lowest amplitude of voice refers to the loudest and a gentle voice respectively. The low singing amplitude could be responsible for the pleasantness of the voice experienced by the subjects. In the present study, we can infer that significant change in the singing low amplitude and singing amplitude range may be due to some improvement in the pulmonary functions by the practice of BP, which is well established.^[5,6]

A formant frequency is a frequency at which the energy is boosted due the vocal tract shape and size. We may infer that reduction in the second formant values is due to the increased pharyngeal cavity that occurred during humming. This suggests that there could be an enlargement of pharyngeal cavity of the vocal tract, leading to the improvement in voice after 30 days of practice of BP.

Considerable changes are seen in the values of Fundamental Frequency and Fundamental frequency range may be because the Fundamental Frequency and Fundamental Frequency Range are concerned more with the phonatory system, rather than the resonatory and respiratory system. Thus, in the present study, BP has shown significant effect on resonatory system followed by respiratory system, than on the phonatory system

Discussion on Observations

Improvement in the sleep quality of subjects of this study may be due to the release of nitric oxide by the practice of BP as its practice, releases nitric oxide in the body which helps in improving memory and behaviour by transmitting information between neurogenic cells in the brain, apart from calming the brain by improving the quality of sleep.^[11] Improvement in vocal prolonging (attribute of singing voice involving respiration) may be due to improvement of various pulmonary functions by the practice of *Bhramari Pranayama*.^[8,9] Attainment of the vocal stability after the practice of BP may be because the constant and repeated humming during BP.

Extension of the ranges of frequency and amplitude allow the vocalists to reach high and low

itches easily. In this study, reduction in the vocal strain may be due to the increase in the singing amplitude range which is witnessed significantly ($p < 0.01$) in most of the subjects.

Pleasantness of voice may be due to the significant reduction in the lowest singing amplitude values, leading to reduction in the loudness of voice (perceptual attribute of amplitude) thus, making the voice more pleasant. Also pleasantness may be due to reduction of the vocal roughness and perturbation measures by the virtue of humming.^[12]

The head ache experienced by the subjects could be due to vibrations that develop in the frontal, maxillary, and temporal regions of the head during humming and the heaviness could be due to the resonance effect that is produced in the head region due to humming in *Bhramari Pranayama*.

CONCLUSION

The effect of BP on the resonatory system was noteworthy. It has some considerable effect on the respiratory system and the phonatory system in the current study, BP improved the resonance characteristics of the voice and there by improved the quality of singing voice in prospective singers. Thus *Bhramari Pranayama* can be taken as a voice culturing technique in prospective singers and other professional voice users.

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