

Impact of Fast and Slow Pranayam on Cardio Vascular Autonomic Function among Healthy Young Volunteers: Randomized Controlled Study

Sharma VK¹, Dinesh T², Rajajeyakumar M^{3*}, Grrishma B⁴ and Bhavanani AB⁵

¹Department of Physiology, Government Institute of Medical Sciences, Uttar Pradesh, India

²Department of Physiology, Government Thiruvavur Medical College, Thiruvavur, Tamilnadu, India

³Department of Physiology, Trichy SRM Medical College Hospital and Research Centre, Tiruchirappalli, Tamilnadu, India

⁴Department of Physiology, Yenepoya Medical College, Mangalore, Karnataka, India

⁵CYTER, Sri Balaji Vidyapeeth University, Puducherry, India

*Corresponding author: Rajajeyakumar M, Department of Physiology, Trichy SRM Medical College Hospital and Research Centre, Tiruchirappalli, Tamilnadu, India, Tel: 9751382650; Email:rajakumar60@gmail.com

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Abstract

Background: Pranayama refers to the conscious manipulation of the breath in order to modulate the cosmic energy (prana) from the air in the environment. The techniques of Pranayam include practices that are performed in a slow or fast type.

Aim: Investigate and correlate the impact of three months practice of fast and slow pranayam on cardiovascular autonomic function among healthy young volunteer.

Materials and Methods: Total of 75 volunteer subjects were randomized into control group (Group1: n=25), fast pranayama group (Group 2: n=25) and slow pranayama group (Group 3: n=25). The pranayam practice (Slow Pranayam Group-Savitri, Pranav and Nadisodhana: Fast Pranayam Group-Bhastrika, Kukkuriya and Kapalabhati, were practiced 30 minutes per day, 3 days per week for 3 months either slow or fast pranayam by a certified yoga teacher. The recording of Short term Heart Rate Variability (HRV) was done at the before and after 3 months of study period.

Result: The LF/HF ratio which is the best indicator of Sympathovagal balance was reduced significantly in slow pranayam group showing a shifting of balance towards parasympathetic tone. The RMSSD which is considered to be the best predictor of parasympathetic tone significantly increased in slow pranayam group. A significant increase (HF) nu and decrease (LF) nu was noted in slow and fast pranayam respectively after yoga intervention.

Conclusion: Results of our study demonstrates that slow and fast pranayam practices are more effective to maintain sympatho-vagal balance by modulating sympathetic and parasympathetic division of autonomic nervous system.

Keywords Fast pranayam; Heart rate variability; Sympathovagal balance; Slow pranayam; Young adults

Introduction

Yoga is the ancient scientific and cultural heritage of India and dates back for more than 6000 years. The techniques of Yoga include conscious stretching and holding of different poses (asanas), contemplative meditation and conscious expansion of energy (prana) in various breathing techniques (pranayama) [1]. Most popular paths of Yoga worldwide, include hatha yoga, raja yoga, bhakthi yoga, karma yoga, tantra yoga and integral yoga [2].

Pranayama refers to the conscious manipulation of the breath in order to modulate the cosmic energy (prana) from the air in the environment. The techniques of Pranayama include practices that are performed in a slow or fast manner [3]. The practice of pranayama on a regular basis improves cardio-vascular and respiratory functions by increasing parasympathetic tone, decreasing the effect of stress and

strain on the body in addition to improving physical and mental health [4-6]. Heart Rate Variability (HRV) is an index of autonomic balance of an individual. It is defined as oscillations between consecutive heartbeats and it is considered as a physiological phenomenon [7]. Existing scientific literature proves the short term practice of slow pranayama enhances the vagal tone and reduces the adrenergic tone of an individual. There are also evidences stating that short term practice of fast pranayama increases sympathetic tone [8,9]. Very few available scientific literatures were investigate and to correlate the impact of three months practice of fast and slow pranayam on cardio vascular autonomic function among healthy young volunteer.

Materials and Methods

This study was a collaborative work between the Advanced Centre for Yoga Therapy Education and Research (ACYTER) and Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry.

Study design

After obtaining approval from the JIPMER scientific advisory and human ethics committee this study was started. Total 75 convenient healthy volunteers between the age group of 18-25 years, from medical and paramedical courses in JIPMER, were recruited by simple random technique using student's attendance register as sampling frame after meeting inclusion and exclusion criteria. Subjects who practiced yoga before, athletes and volunteers with recent or past known organic diseases were excluded from this study. The benefits of pranayam training were explained to the study volunteers, motivated to participate and written, informed consent was taken from all of them.

Volunteers were requested to report to the autonomic function testing laboratory, department of Physiology, at JIPMER between 8-9 am, two hours after light breakfast with loose clothing. The volunteers were requested to avoid physical activity for at least one day prior to HRV recording, alcohol consumption, nicotine, caffeinated beverages and drugs known to influence the cardiovascular autonomic functions. The study procedure was briefly explained to all the volunteers in the recording of HRV. A room temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ was maintained.

Recording of short-term HRV was done in the following manner: participants were asked to lie in supine position on a couch and to completely relax with comfortable lighting and temperature. The subjects were informed to relax for 10 minutes. They were connected with appropriate transducers and ECG (lead II), digital pulse waveforms and respiration were recorded at 500 samples/ second using BIOPAC-MP-100 data acquisition system with Acknowledge 3.8.2 software and Nihon Kohden polygraph. The obtained 5 minute resting lead II ECG was filtered using band pass filters and carefully analyzed for ectopics and artifacts which, if present were removed manually. The detection of R waves was done with a threshold algorithm of Lab chart pro software. From the RR tachogram both the time domain and the frequency domain measures were computed using HRV analysis software (Kubio's HRV, version 1.1 Finland).

Power spectral analysis was done by Fast Fourier Transformation and the frequency domain indices obtained includes high frequency (HF 0.15 to 0.4 Hz), low frequency (LF 0.04 to 0.15 Hz), very low frequency (VLF 0.003 to 0.04 Hz), and both in absolute powers given as ms^2 and in normalized unit (nu).

The time domain measure consists:

1. Mean and standard deviation of RR intervals (SDNN in ms)
2. Square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD in ms)
3. Adjacent RR interval differing more than 50 ms in the entire recording (NN50),
4. Percentage of NN50 counts (NN50 divided by total number of all the RR intervals) (pNN50).

HF, SDNN, RMSSD, NN50, and pNN50 reflect cardio vagal tone. LF interpreted and reflects both parasympathetic and sympathetic nervous system. VLF component's interpreted using 24 hours HRV recordings and LF/HF ratio denotes autonomic balance. [7].

Thereafter, all the volunteers were divided into Group 1 (n=25), Group 2 (n=25) and Group 3 (n=25) by simple randomization method using random number tables. Out of 75 volunteers, 38 females and 37 males were included for this study.

Group 1 (n=25): Control group volunteers were not practiced pranayam.

Group 2 (n=25): Volunteers of this group practiced the following slow pranayam techniques:

Nadishodhana
Pranava
Savitri

Group 3 (n=25): Volunteers of this group practiced the following fast pranayama techniques:

Kapalabhati
Bhastrika
Kukkriya

Pranayama training

The details of the pranayam training have been explained in our previous publications [10,11]. Volunteers were practiced pranayam in a well-ventilated and illuminated room maintained at the temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Certified yoga teacher administered the pranayam sessions to Group 2 and Group 3 volunteers for 30 minutes per day, 3 times per week for the duration of 3 months in the Department of ACYTER (Guidelines of Morarji Desai National Institute of Yoga, New Delhi was followed). An attendance register was maintained for the same. Rests of the days, the study volunteers were motivated to practice at their home. The yoga instructor gave 1 week of practice sessions to both Group 2 and 3 volunteers, before starting the pranayam practice to familiarize them. The techniques used for fast and slow types of pranayam were as described in the literature [10-13]. The pranayam practice session were conducted for Group 2 and Group 3 volunteers as follows:

1. **Control Group** did not practice any type of pranayam technique during the 3 months study period.

2. **Fast Pranayama:** Each cycle consists of 6 minutes duration, it includes 1 minute of Bhastrika, Kapalabhati, and Kukkuriya pranayam in-between 1 minute of rest of each pranayam practice. Volunteers were requested to complete 3 cycles in each session

- Bhastrika pranayam (thoracic breathing): Volunteers were instructed inspire deeply followed by forced expiration following one another in a rapid succession. This is known as 'bellow' type of breathing. One round consists of 10 such 'bellows'.
- Kapalabhati pranayam: Volunteers were asked to perform Vajrasana and exhale forcefully. It consists of active expiration but the inspiration was passive.
- Kukkriya pranayam (dog panting with Vajrasana posture): The volunteers were instructed to open the mouth wide and the tongue was pushed out as far as possible. Then, they inhaled and exhaled at a rapid rate with their tongue hanging out of their mouth. After 10 such rounds, relaxation was done in same Vajrasana posture.

3. **Slow Pranayam:** One round consists of practicing 2 minutes of Savitri, Nadishodhana, and pranava pranayam with 1 minute rest in between each pranayam. Volunteers were asked to perform nine rounds according to their capacity with comfortable posture (sukhasana).

- Savitri pranayam is a slow, deep and rhythmic breathing. Each cycle has a ratio of 6:3:6:3 between inhalation (purak), held-in breath (kumbhak), exhalation (rechak) and held out breath (shunyak) phases of the respiratory cycle.

- Nadishodhana pranayam is slow, rhythmic and alternate nostril breathing. Each round consisted of inspiration through one nostril, expiration through other nostril and viceversa.
- Pranava pranayam is a slow, deep and rhythmic breathing, where emphasis is placed on making the sound AAA, UUU and MMM while breathing out for two to three times the duration of the inhaled breath. This technique consisting of Adham Pranayam or lower chest breathing (sound of AAA), Madhyam Pranayam or mid-chest breathing (sound of UUU), Adhyam Pranayam or upper chest breathing (sound of MMM) and final the union of all the three parts in a complete yogic breathing (Mahat Yoga Pranayam). At the end of the session, both Group 2 and 3 volunteers were instructed to lie down in shavasana and relax for 10 minutes.

All the parameters were recorded before and after 3 months of study period.

Statistical analysis

Data analysis was done with Statistical Package for Social Sciences version 19.0 for Windows (SPSS Inc., Chicago, Illinois, USA). One way ANOVA was performed to compare the baseline age distribution between the groups. Gender distribution between the groups was compared by the Chi-square test.

Since the outcome variables followed non normal distribution, nonparametric test was used as test of significance. Kruskal-wallis test was used to compare the difference of the pre and post-test variables. To compare between the pre and post-test variables Wilcoxon signed rank test was done.

Results

The mean age of the volunteers was 18.58 ± 2.27 years.

Table 1 shows the baseline demographic data such as age and gender showing that there is no age or gender difference between the groups.

Parameters	Group 1	Group 2	Group 3	P value	
Age	18.64 ± 0.95	18.68 ± 1.03	18.56 ± 1.32	0.927	
	n (%)	n (%)	n (%)		
Gender	Male	11(44)	14 (56)	12 (48)	0.668
	Female	14(56)	11(44)	13 (52)	

One way ANOVA was done to analyze the intergroup difference in age; Group 1: control; Group 2: underwent fast pranayama yoga training; Group 3: underwent slow pranayama yoga training

Chi square distribution was done to compare the gender difference among the groups; *P<0.05 , ** P<0.01, ***P<0.001

Table 1: Demographic variables and baseline parameters.

Table 2 shows that, there was no baseline significant difference between all the parameters among three groups before the pranayam practice except pNN50% which was statistically significant between group 1 and 3 and 1 and 2. We found that, there were significant difference in all other HRV parameters among 1 and 3 and 2 and 3 groups after pranayam practice except SDNN which was statistically significant between group 1 and 2 and 2 and 3. The RMSSD which is considered as the best predictor of parasympathetic tone significantly decreased in fast pranayam groups (2) when compared to the control group (1). The HF (ms^2) was increased followed by slow pranayam training (Group 3) compared to control group. No significant difference was seen with total power. LF (ms^2) was decreased significantly in slow pranayam groups. The LF/HF ratio was decreased in slow pranayam groups following yoga intervention with compare to the control group. The LF/HF ratio which is considered as the best indicator of Sympathovagal balance was increased significantly in fast pranayam groups indicates a shift of the autonomic balance towards sympathetic tone.

Parameters		Group 1	Group 2	Group 3	P
Time domain parameters					
SDNN(ms)	pre	80.08 ± 5.82	77.58 ± 8.85	78.14 ± 4.92	0.207
	post	79.89 ± 4.34###	71.71 ± 12.66	79.49 ± 4.18**	0.002
RMSSD(ms)	pre	80.95 ± 4.60	84.4 ± 11.35	80.82 ± 7.84	0.981
	post	78.27 ± 5.45\$\$\$	80.08 ± 11.46	89.64 ± 6.29***	<0.001
pNN50(%)	pre	34.18 ± 1.93\$\$\$	33.72 ± 2.72	24.72 ± 2.54***	<0.001
	post	34.23 ± 2.15\$\$\$	32.81 ± 2.59	28.94 ± 4.2***	<0.001
Frequency domain parameter					
TP(ms2)	pre	4471 ± 366.39	4423 ± 422.53	4535 ± 346.46	0.35
	post	4439 ± 553.30	4366 ± 375.16	4660 ± 399.70	0.06
LF(ms2)	pre	1593.01 ± 342.91	1221 ± 315.13	1595.15 ± 357.11	0.55
	post	1565 ± 380.75\$\$\$	1499.34 ± 308.67	1227 ± 241.35***	<0.001
HF(ms2)	pre	1641 ± 334.08	2081 ± 241.59	1703 ± 266.16	0.824

	post	1644 ± 350.94\$\$\$	1603 ± 274.35	2204 ± 277.90***	<0.001
LFnu	pre	43.65 ± 2.18\$	44.64 ± 1.67	44.96 ± 2.23	<0.04
	post	42.95 ± 2.68\$\$	46.31 ± 1.40##	40.97 ± 1.67**	<0.002
HFnu	pre	56.34 ± 2.18\$	55.35 ± 1.67	55.03 ± 2.23	<0.04
	post	57.04 ± 2.68\$	53.68 ± 1.40#	59.02 ± 2.64*	<0.01
LF/HF ratio	pre	1.04 ± 0.44	0.89 ± 0.17	0.97 ± 0.33	0.65
	post	1.01 ± 0.42\$\$\$	0.913 ± 0.25	0.56 ± 0.14***	<0.001

Kruskal-wallis test was used to compare the pre and post HRV parameters and relevant post hoc test was performed for the significant values. Group 1 control; Group 2: underwent fast pranayama yoga training; Group 3: underwent slow pranayama yoga training. SDNN: Standard deviation of NN intervals; RMSSD: Square root of mean squared differences of successive NN intervals; pNN50: percentage of NN50; VLF: LF: low frequency; HF: high frequency; TP: total power; LF nu: Low frequency in normalized units, HF nu: High frequency in normalized units.

*P<0.05, ** P<0.01, ***P<0.001; #: Comparison between group 1 and 2; *: Comparison between group 2 and 3; \$: Comparison between group 1 and 3

Table 2: Comparison of HRV pre and posttest parameters between the groups.

Table 3 shows the comparison of pre and post-test HRV parameters between all three groups. There was no significant difference in pre and post pranayam practice in the control group (I). LF (ms²), LF nu were significantly increased (p<0.001) and HF (ms²), HF nu decreased (p<0.001) in Group 2 (Fast pranayam group). LF (ms²), LF nu were significantly (p<0.001) decreased and HF (ms²), HF nu increased (p<0.001) in Group 3 (slow pranayam group). pNN50 (%) increased and LF/HF ratio was decreased in group 3. These difference being were statistically significant (p<0.001). This indirectly reflects predominance of parasympathetic activity of autonomic nervous system. However, there was an increase in total power of both slow and fast pranayam

groups after 3 months of study period when compared to the control group but this increase was not statistically significant. Statistically significant decrease in LF (ms²) was noted with slow pranayam group after the practice. Increased HF (ms²) was observed for slow pranayam group and no such improvement was seen in control group. This was reflected in their normalized units with a notable decrease in LF nu and marked increase in HF nu in slow pranayam group. The LF/HF ratio which is considered as the best indicator of Sympathovagal balance was reduced significantly in slow pranayam groups indicates a shift of the autonomic balance towards parasympathetic tone.

Parameters		Group 1 (n=25)	p	Group 2 (n=25)	p	Group 3 (n=25)	p
SDNN(ms)	pre	80.08 ± 5.82	0.896	77.58 ± 8.85	0.063	78.14 ± 4.92	0.3
	post	79.89 ± 4.34		71.71 ± 12.66		79.49 ± 4.18	
RMSSD(ms)	pre	80.95 ± 4.60	0.708	84.4 ± 11.35	0.874	80.82 ± 7.84	0.384
	post	78.27 ± 5.45		80.08 ± 11.46		89.64 ± 6.29	
pNN50(%)	pre	34.18 ± 1.93	0.931	33.72 ± 2.72	0.231	24.72 ± 2.54	0.001&&&
	post	34.23 ± 2.15		32.81 ± 2.59		28.94 ± 4.2	
LF (ms²)	pre	1593.01 ± 342.91	0.785	1221 ± 315.13	0.002@@	1595.15 ± 357.11	0.001&&&
	post	1565 ± 380.75		1499.34 ± 308.67		1227 ± 241.35	
HF (ms²)	pre	1641 ± 334.08	0.975	2081 ± 241.59	0.001@@@	1703 ± 266.16	0.001&&&
	post	1644 ± 350.94		1693 ± 274.35		2204 ± 277.90	
Total power	pre	4471 ± 366.39	0.815	4423 ± 422.53	0.616	4535 ± 346.46	0.243
	post	4439 ± 553.30		4366 ± 375.16		4660 ± 399.70	
LF/HF ratio	pre	1.04 ± 0.44	0.806	0.89 ± 0.17	0.742	0.97 ± 0.33	0.001&&&
	post	1.01 ± 0.42		0.913 ± 0.25		0.56 ± 0.14	
LFnu	pre	43.65 ± 2.28	0.304	44.64 ± 1.76	0.002@@	55.03 ± 2.23	0.001&&&

	post	42.95 ± 2.08		46.31 ± 1.94		59.02 ± 2.64	
HFnu	pre	56.34 ± 2.18	0.316	55.35 ± 1.67	0.004@@	55.03 ± 2.37	0.001&&&
	post	57.04 ± 2.68		53.68 ± 1.40		59.02 ± 2.96	

The data was expressed in median (interquartile range) Wilcoxon signed rank test was done to compare the pre and post values between the groups ; P<0.05 is considered to be significant; Group 1: control; Group 2: underwent fast pranayama yoga training; Group 3 : underwent slow pranayama yoga training; SDNN: Standard deviation of NN intervals; RMSSD: Square root of mean squared differences of successive NN intervals; pNN50: percentage of NN50;VLF: LF: low frequency; HF: high frequency; TP: total power ; LF nu : Low frequency in normalized units, HF nu: High frequency in normalized units.*P<0.05 , ** P<0.01, ***P<0.001; @: Comparison between pre post of group 2; &: Comparison between pre post of group 3

Table 3: Comparison of difference in HRV parameters between the groups.

Discussion

Pranayam acts as a connection between the body and mind. It involves alter the breathing pattern, which consists of three phases: purak (inspiration), kumbhak (holding) and rechak (expiration) that can be practiced either in a slow or fast pranayam [14]. HRV is considered as a non-invasive marker of cardiac autonomic activity. Decreased HRV is considered as a significant cardiovascular risk factor which occurs due to autonomic dysfunction [15]. It is also associated with early onset of pre hypertension and other cardiovascular diseases. Furthermore, increased sympathetic and decreased parasympathetic modulations are markers of poor cardiovascular health as evidenced from various previous studies on patients with myocardial infarction [16,17]. Results of our study indicate that there was an increase in all the parasympathetic parameters in slow pranayam group and all the sympathetic parameters were significantly increased in the fast pranayam group. Findings in our study are in line with the previous studies by Khattab et al. [18] and Pinheiro et al. [19] which showed a significant increase in these parameters.

RMSSD, NN50, and pNN50 are the measurements of short-term variation to estimate the parasympathetic activity, showed a significant increase in slow pranayam group when compared with the control group. Previous studies by Khattab et al. [18] and Punita et al. [20] also showed a significant increase in RMSSD and NN50, which is in consistent with our present study. In contrast to our findings, Telles et al. [21] showed a significant decrease in NN50 and pNN50 with high frequency breathing, which is associated with an increased sympathetic tone. Other studies have reported by Raghuraj et al. [22] and Telles et al. [21] a significant increase in LF:HF ratio immediately after pranayama practice (high frequency breathing), suggesting an increase in sympathetic tone.

Slow pranayam are deep breathing exercises performed at different frequencies of respiration. In the training of both slow and fast pranayam practices, participants intentionally focus on breathing and intend to relax and attention is drawn away from the external distracting stimuli. With regular pranayam practice, the ability of the participants to concentrate will be enhanced and it changes mental processing (e.g., focused attention and reduced stress) which can be rapidly expressed in the body *via* the autonomic and neuro-endocrine systems [23]. A study by Jerath et al. [24] has hypothesized about the interaction of pranaya breathing with the nervous system affecting metabolism and autonomic functions. During the above, tidal inspiration (as seen in Hering Breuer's reflex), stretch of the lung tissue produces inhibitory signals by stimulating the slowly adapting stretch receptors. Stretch of the connective tissue (fibroblasts) localized around the lungs generates hyperpolarization currents. This will be

propagated through neural and non-neural tissues and both of them cause synchronization of neural elements in heart, lungs, limbic system and cortex. Inhibitory current synchronizes rhythmic cellular activity between cardiopulmonary center and central nervous system that regulates excitability of nervous tissues indicates a state of relaxation. Hyperpolarization of tissues usually manifests in a parasympathetic like change. Synchronization within the hypothalamus and the brain-stem is mainly responsible for the parasympathetic response. Modulation of the nervous system that leads to a decrease in metabolic activity is an indicative of the parasympathetic state [23].

The effect of pranayam on stress reduction might be mediated by the bidirectional vagal system. Vagal afferents from peripheral receptors are connected with the nucleus tractus solitarius from where fibers ascend to the thalamus, limbic areas and anterior cortical areas. At different levels of the neuraxis the descending projections then modulate autonomic, visceral, and stress arousal mechanisms [12,13,24-26]. The bottom-up mechanisms of pranayam practice may be induced through the stretch of respiratory muscles, specifically the diaphragm.

Though not statistically significant (p=0.07), there was a greater magnitude of change shown in the slow pranayama group with respect to HF and overall power. It is possible that this would attain statistical significance in the future studies with more number of volunteers and with long term training.

Conclusion

The results of our present study demonstrates that slow pranayam practices are more effective in reducing the sympathetic over activity and produces a parasympatho-dominance state by enhancing vagal tone and vice versa.

Limitations

Beat-to-beat noninvasive BP recording was not done. Hence, BP variability and baroreflex sensitivity could not be determined in our volunteers. In future, we have planned to include biochemical parameters such as vanillylmandelic acid, metanephrines, which can substantiate the reduction in sympathetic activity after slow pranayam training. Since, this study was conducted only on healthy young volunteers, we recommend that, new research studies should broaden the current research and to include clinical populations such as patients with diabetes and hypertension.

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