DOI: 10.7860/JCDR/2014/7256.3668

Effect of Fast and Slow Pranayama Practice on Cognitive Functions in Healthy Volunteers

VIVEK KUMAR SHARMA[1], RAJAJEYAKUMAR M.[2], VELKUMARY S.[3], SENTHIL KUMAR SUBRAMANIAN[4], ANANDA B. BHAVANANI[5], MADANMOHAN[6], AJIT SAHAI[7], DINESH THANGAVEL[8]

ABSTRACT

Objectives: To compare the cumulative effect of commonly practised slow and fast pranayama on cognitive functions in healthy volunteers.

Settings and Design: 84 participants who were in self-reported good health, who were in the age group of 18-25 years, who were randomized to fast pranayama, slow pranayama and control group with 28 participants in each group.

Material and Methods: Fast pranayama included kapalabhati, bhastrika and kukkuriya. Slow pranayama included nadishodhana, Pranav and Savitri. Respective pranayama training was given for 35 minutes, three times per week, for a duration of 12 weeks under the supervision of a certified yoga trainer. Parameters were recorded before and after 12 weeks of intervention: Perceived stress scale (PSS), BMI, waist to hip ratio and cognitive parameters-letter cancellation test, trail making tests A and B, forward and reverse digit spans and auditory and visual reaction times for red light and green light.

Statistical Analysis: Inter–group comparison was done by one way ANOVA and intra group comparison was done by paired t-test.

Results and Conclusion: Executive functions, PSS and reaction time improved significantly in both fast and slow pranayama groups, except reverse digit span, which showed an improvement only in fast pranayama group. In addition, percentage reduction in reaction time was significantly more in the fast pranayama group as compared to that in slow pranayama group. Both types of pranayamas are beneficial for cognitive functions, but fast pranayama has additional effects on executive function of manipulation in auditory working memory, central neural processing and sensory-motor performance.

Keywords: Pranayama, Cognitive functions, Reaction time

INTRODUCTION

Anxiety, stress and mental tensions have become almost inevitable companions of human life at all cross sections of populations [1]. Studies have reported higher perceived stress among students in healthcare courses, including dental, medical and nursing courses [2-5], as compared to students from other fields. Yoga and pranayama are ancient sciences which originated in India, which can be practised to combat stress [6]. Pranayama involves manipulation of the breath and it consists of three phases: "puraka" (inhalation); "kumbhaka' (retention) and "rechaka" (exhalation) [7,8]. Pranayama can be practised as either fast or slow pranayamas. Both fast and slow pranayamas are beneficial [9-11], but their physiological responses are different in healthy participants [12]. Executive functions refer to cognitive processes that regulate, control, and manage other cognitive processes [13]. Executive functions include working memory, concentration span, scanning and retrieval of stored information and mental flexibility, i.e. the ability to shift from one criterion to another in sorting or matching tasks [14,15]. Perceived stress has a negative impact on executive functions [16,17]. There is a paucity of data on evaluation of the cumulative effect of commonly practised slow and fast pranayamas on cognitive parameters such as attention span, executive functions, perceived stress and reaction time. Therefore, the current study aimed to compare the effects of twelve weeks of fast and slow pranayama training on these parameters in young healthcare students.

MATERIAL AND METHODS

This study was conducted in the Department of Physiology, JIPMER, Pondicherry India, during May 2011 to December 2011. Yoga training was given at the Advanced Centre for Yoga Therapy Education and Research (ACYTER), JIPMER, Pondicherry. The study was commenced after obtaining approval from the institute's scientific advisory committee and human ethics committee.

Participants

We considered volunteers who were in the age group of [18-25] years, who were in self-reported good health, who were undergoing various healthcare courses (medical, nursing and allied medical sciences). We excluded volunteers who had practised yoga in the past one-year and those with current or previous mental or neurological diseases. We explained the study design to the volunteers and made them aware that their participation would remain anonymous and that they had the freedom to withdraw from the study at any time.We included only those who gave their written informed consents to participate in the study (n=84).

Parameters Measured

1. Height
2. Weight
3. Cognitive Functions Test Battery [19]
    - Letter Cancellation Test (LCT)
    - Trail Making Test A (TTA)
    - Trail Making Test B (TTB)
    - Forward digit span (FDS)
    - Reverse digit span (RDS)
4. Reaction time (RT)

Reaction time for the detection of auditory (ART) and visual signals (red and green lights) (VRT- R and VRT – G respectively) was recorded on apparatus supplied by Ananda agencies (Pune, India). RT is an indirect index of the processing capacity of the central nervous system, and it is a simple and inexpensive method of determining sensorimotor performance [20].

Study design

The persons involved in the recording of the parameters and the analysis of data were blind to the experimental conditions (i.e. the group that the participants belonged to).

We familiarized the participants with the test batteries and gave them adequate practice on the reaction time apparatus on two separate occasions, to produce results that were more consistent. On the day of assessment, participants reported to the Department of Physiology, JIPMER, between 9 and 10 AM, at least two hours after eating a light breakfast. Then, the above-mentioned parameters were recorded. We administered these tests in the same order as are given here, to all the participants.

Then, the participants (n=84) were randomly assigned into three groups:

1. **Fast pranayama group (n = 28):** Kapalabhati, Bhastrika and Kukkriya.
2. **Slow pranayama group (n = 28):** Nadishodhana, Pranava and Savitri.
3. **Control group (n = 28):** No pranayama intervention. All the parameters were recorded again after 12 weeks of intervention.

Intervention

We trained the participants in their respective pranayama technique for one week, before the start of the intervention period. Pranayama intervention was carried out for about thirty-five minutes a day, three times per week, for a duration of 12 weeks. A certified yoga trainer at ACYTER gave the Pranayama training and intervention. Participants practised the pranayama in a quiet room which was maintained at a comfortable temperature (25 ± 2ºC). We followed pranayama techniques followed in ACYTER, JIPMER 21. Typical sessions of fast and slow pranayamas were as follows:

Fast Pranayama: Each cycle (6 minutes) consisted of practising one minute of Kapalabhati, one minute of Bhastrika and one minute of Kukkriya pranayamas, interspersed with one minute of rest between each pranayama. Participants were asked to complete 4 cycles in each session (24 minutes).

Slow Pranayama: Each cycle (9 minutes) consisted of practising two minutes of Nadishodhana, two minutes of Pranava and two minutes of Savitri pranayamas which were interspersed with one minute of rest between each pranayama. While they were sitting in a comfortable posture (sukhasana), participants were asked to perform three rounds per session (27 minutes).

STATISTICAL ANALYSIS

Power and sample size software, version 3.0 was used to calculate the adequate sample size (at assumed power of 90%) which was required for the study and to analyze the post–test power of the study. Analysis of the data was done by using IBM SPSS, version 19. The normality of the data was tested by Kolmogorov–Smirnov test. Intergroup comparison was done using one way ANOVA, followed by Tukey Krammer post–hoc test for pair wise comparisons. Intragroup comparisons were done by using paired t-test for parametric measures and Wilcoxon signed rank test was used for non-parametric measures. Chi-square test was used to compare intergroup gender distributions. The Mann Whitney U-test was used to compare the percentage change between groups. A p value less than 0.05 was considered to be statistically significant.

RESULTS

A post-test analysis, revealed that the lowest power of the study with a mean RDS difference of 0.36 (SD=1.13) between fast and slow pranayama groups was 85%, which showed that the sample size was adequate and that the strength of the study was good.

There were no significant differences in age, height or weight between the three groups [Table/Fig-1]. There was no significant difference in gender distribution between the groups. The 3 groups were comparable in executive functions and attention span before the intervention [Table/Fig-2]. There was a significant decrease in LCT (time) (p<0.001), number of omissions in LCT (p<0.001), total time taken for TTA (p<0.001), total time taken for TTB (p<0.001), ART (p<0.001) and VRT (both green and red light) (p<0.005) in both the study groups but not in the control group after the study period (12 weeks). We have also observed that practice of fast and slow pranayama lead to siginificant decrease in Perceived stress scale scores [18]. In addition, a significant improvement was seen among participants of both fast pranayama group and slow pranayama group in FDS (p<0.001), whereas a change in RDS was seen only in fast pranayama group participants.

There were no significant differences in the percentage of change from pre- to post-test between fast and slow pranayama groups in stress scores and in all of the executive function parameters. However, the fast pranayama group showed a significantly improved performance as compared to the slow pranayama group

Parameters	Fast pranayama group (n=28)	Slow pranayama group (n=28)	Control group (n=28)
Age (years) (Mean ± SD)	18.39 ± 1.133	19.28 ± 1.82	19.0 ± 1.56
Height (cm) (Mean ± SD)	158.46 ± 7.30	157.33 ± 9.42	157.25 ± 8.86
Weight (Kg) (Mean ± SD)	49.63 ± 6.12	51.82 ± 11.65	50.21 ± 9.26
Gender			
Male	5	4	5
Female	23	24	23

[Table/Fig-1]: Comparison of subject's characteristics amongst three groups. *P<0.05; **P<0.01; ***P<0.001. One way ANOVA test for intergroup comparison of Age, Height & Weight. Chi-square test for comparison of intergroup gender distribution

Parameters		Fast pranayama group (n=28)	Slow pranayama group (n=28)	Control group (n=28)
LCT (time in sec)	Pre	114.03 ± 17.13	104.89 ± 19.20	111.36 ± 18.74
	Post	104.17 ± 114.15***	89.32 ± 19.37***	109.36 ± 24.05
LCT (omissions)	Pre	2.64 ± 2.52	1.36 ± 1.54	0.86 ± 0.97
	Post	0.71 ± 1.08***	0.42 ± 0.69**	0.70 ± 1.08
LCT (commission)	Pre	0.035 ± 0.18	0.03 ± 0.18	0.06 ± 0.25
	Post	0.071 ± 0.62	0.07 ± 0.26	003 ± 0.18
TTA (in sec)	Pre	73.60 ± 23.4	65.12 ± 14.96	74.10 ± 11.64
	Post	58.67 ± 21.62***	51.89 ± 13.14***	72.10 ± 12.95
TTB (in sec)	Pre	104.57 ± 26.50	97.05 ± 24.36	106.73 ± 34.45
	Post	83.96 ± 18.94***	85.39 ± 25.47***	98.46 ± 33.47
FDS	Pre	6.03 ± 0.83	6.00 ± 0.94	5.93 ± 1.36
	Post	6.75 ± 1.07***	6.42 ± 0.71*	5.73 ± 1.25
RDS	Pre	4.14 ± 0.80	4.21 ± 0.95	3.83 ± 1.14
	Post	4.50 ± 1.07*	4.57 ± 1.13	3.80 ± 1.32
ART (msec) †	Pre	188.99 ± 30.36	186.61 ± 30.43	189.54 ± 28.08
	Post	154.89 ± 29.10***	167.58 ± 23.99***	189.76 ± 26.61
VRT–R (msec) †	Pre	219.79 ± 35.21	208.11 ± 37.02	221.88 ± 34.45
	Post	177.85 ± 22.22***	189.32 ± 40.19*	222.0 ± 27.79
VRT-G (msec) †	Pre	240.70 ± 39.44	226.53 ± 41.67	222.68 ± 31.69
	Post	186.31 ± 28.02***	206.32 ± 39.02*	223.21 ± 30.04
PSS	Pre	19.21 ± 4.33	19.21 ± 4.38	20.57 ± 3.17
	Post	14.42 ± 4.14***	13.89 ± 2.94***	19.82 ± 3.41

[Table/Fig-2]: Comparison of pre test and post test values of cognitive test parameters and reaction time in three groups (Mean ± S.D). LCT- letter cancellation test, TTA – Trial test A, TTB – Trial test A , FDS- Forward digit span, RDS- Reverse digit span, ART – Auditory reaction time, VRT–R – Visual reaction time for red, VRT-G – Visual reaction time for green, PSS- Perceived stress score. *P<0.05; **P<0.01; ***P<0.001; Pre-Post analysis was done by wilcoxon signed rank test. †Pre-Post analysis was done by Students paired 't' test; #P<0.05; ##P<0.01; ###P<0.001; #Intergroup analysis of pre values between groups was done by One way ANOVA

Parameters	Fast pranayama group (n=28)	Slow pranayama group (n=28)
LCT (time in sec)	7.82 ± 10.91	13.24 ± 15.10
LCT (omissions)	52.45 ± 43.32	35.57 ± 52.36
LCT (commission)	3.57 ± 18.98	-0.035 ± 0.188
TTA (in sec)	18.47 ± 19.92	15.87 ± 23.06
TTB (in sec)	17.65 ± 17.25	7.23 ± 28.66
FDS	-13.1 ± 20.32	-9.29 ± 14.83
RDS	-9.52 ± 19.74	-10.62 ± 32.94
ART (msec)	16.72 ± 16.38*	8.31 ± 15.27
VRT–R (msec)	17.33 ± 14.91*	8.42 ± 16.32
VRT-G (msec)	20.72 ± 16.80**	7.89 ± 12.75
PSS	23.47 ± 20.38	23.04 ± 18.31

[Table/Fig-3]: Comparison of percentage difference between groups.
LCT- letter cancellation test, TTA – Trial test A, TTB – Trial test A , FDS- Forward digit span, RDS- Reverse digit span, ART – Auditory reaction time, VRT–R – Visual reaction time for red, VRT-G – Visual reaction time for green, PSS- Perceived stress score. Analysis was done using Mann Whitney U test. *P<0.05; **P<0.01; ***<0.001

in ART, VRT-R (P<0.05) and VRT-G (P<0.01) [Table/Fig-3].

DISCUSSION

According to the traditional wisdom of yoga, pranayama is the key to bringing about psychosomatic integration and harmony.

Specifically, we observed a significant reduction in perceived stress and improvement in the following cognitive domains: attention, visuo-motor speed and memory retention capacity in both fast and slow pranayama groups. Prefrontal cortex regulates physiological functions by integrating information from ongoing cognitive processes, emotional processes and current stress level [14,22]. Chronic (perceived) stress alters normal patterns of prefrontal cortex activation during cognitive tasks, resulting in enhanced autonomic arousal [14,22]. The reduced stress in both pranayama groups could have enabled their improved cognitive functions. Our results were consistent with those of previous studies, which found significant improvement in various cognitive domains with the practice of different yoga breathing techniques [10,23-25].

In the present study, it was not possible to determine the mechanism of action of pranayama techniques, but we hypothesized that the improvements in cognitive functions in pranayama groups may have occurred due to reduced stress and improved parasympathetic tone.

The particular contribution of pranayama to stress reduction might be mediated by the bidirectional vagal system. Vagal afferents from peripheral receptors are connected with the nucleus tractus solitarius from which fibres ascend to the thalamus, limbic areas and anterior cortical areas. The descending projections then modulate autonomic, visceral, and stress arousal mechanisms at the different levels of the neuraxis [26]. The bottom-up mechanisms of pranayama practice may be induced through the stretch of respiratory muscles, specifically the diaphragm [14,26]. During above tidal inhalation (as was seen in Hering Breuer's reflex), stretch of lung tissue produces inhibitory signals in the vagus nerve, which ultimately shifts the autonomic nervous sytem into parasympatho-dominance, that results in a calm and alert state of mind [27].

During both fast and slow types of pranayama practice, when participants intentionally focus on breathing at different frequencies of respiration and intend to relax, attention is drawn away from extraneous distracting stimuli. With continuous pranayama practice, the participants' ability to concentrate is enhanced and the changes in mental processing (e.g., focused attention and reduced stress) are rapidly expressed in the body via the autonomic and neuro endocrine systems. This reorganizes neural representation within the CNS and improves bidirectional communication between the cerebral cortex and the limbic, autonomic, neuro endocrine, emotional, and behavioural activation [22]. Also, generalized alteration in information processing at thalamo-cortical level induces modification in neural mechanisms which regulate the respiratory system [28].

The shortening of auditory and visual RT in our pranayama groups represents greater arousal, better concentration and faster responsiveness [12]. The improvement was significantly greater in the fast pranayama group as compared to that in slow pranayama group. One previous study found insignificant decreases in ART and VRT, with a shorter (three weeks) training period of Savitri (slow breathing) and Bhastrika (fast breathing) pranayamas [12]. Our study, on the other hand, demonstrated that a prolonged practice (12 weeks) of pranayama could be beneficial in reducing RT.

LIMITATIONS OF THE STUDY

There was a difference in training times between the fast and slow pranayama groups (24 vs. 27 minutes), since the participants in the fast pranayama group found it difficult to do more than four rounds in a session. Also, there was a difference in the number of male and female participants in the study. Nevertheless, the male and female participants were equally distributed between the groups, i.e. the gender ratio was almost similar. Since this study was conducted only on healthy participants, future studies should broaden the current research and include clinical populations such as patients with psychiatric disorders, whose cognitive functions are adversely compromised.

CONCLUSION

Slow and rapid types of pranayama are beneficial for stress reduction and for improving cognitive functions, but fast pranayama has additional effects on sensori-motor performance (i.e. faster auditory and visual RT).

DECLARATION FROM THE AUTHORS:

The findings discussed in this research article are a part of the bigger study to evaluate the effect of fast and slow pranayama on various physiological parameters in adolescents. Part of the study has earlier been published in Int J Yoga 2013;6:104-10. [29]

REFERENCES

[1] Sharma VK, Das S, Mondal S, Goswampi U, Gandhi A. Effect of Sahaj Yoga on depressive disorders. *Indian J Physiol Pharmacol.* 2005 Oct; 49(4):462-8.
[2] Birks Y, McKendree J, Watt I. Emotional intelligence and perceived stress in healthcare students: a multi-institutional, multi-professional survey. *BMC Medical Education.* 2009; 9(1):61.
[3] Jones MC, Johnston DW. Distress, stress and coping in first-year student nurses. *J Adv Nurs.* 1997 Sep;26(3):475-82.
[4] Pau A, Rowland ML, Naidoo S, AbdulKadir R, Makrynika E, Moraru R, et al. Emotional intelligence and perceived stress in dental undergraduates: a multinational survey. *J Dent Educ.* 2007 Feb;71(2):197-204.
[5] Shapiro SL, Shapiro DE, Schwartz GE. Stress management in medical education: a review of the literature. *Acad Med.* 2000 Jul;75(7):748-59.
[6] Brown RP, Gerbarg PL. Yoga Breathing, Meditation, and Longevity. Annals of the New York Academy of Sciences. 2009;1172(1):54-62.
[7] Ray S Dutta. Yogic Exercises - Physiologic and Psychic Process. New Delhi: *Jaypee Brother Medical Publishers.* 1998.
[8] Veerabhadrappa SG, Baljoshi VS, Khanapure S, Herur A, Patil S, Ankad RB, et al. Effect of yogic bellows on cardiovascular autonomic reactivity. *J Cardiovasc Dis Res.* 2011 Oct; 2(4):223-27.
[9] Bhavanani AB, Madanmohan, Udupa K. Acute effect of Mukh bhastrika (a yogic bellows type breathing) on reaction time. *Indian J Physiol Pharmacol.* 2003 Jul; 47(3):297-300.
[10] Telles S, Raghuraj P, Arankalle D, Naveen KV. Immediate effect of high-frequency yoga breathing on attention. *Indian J Med Sci.* 2008 Jan; 62(1):20-2.
[11] Udupa K, Madanmohan, Bhavanani AB, Vijayalakshmi P, Krishnamurthy N. Effect of pranayam training on cardiac function in normal young volunteers. *Indian J Physiol Pharmacol.* 2003 Jan; 47(1): 27-33.
[12] Madanmohan, Udupa K, Bhavanani AB, Vijayalakshmi P, Surendiran A. Effect of slow and fast pranayams on reaction time and cardiorespiratory variables. *Indian J Physiol Pharmacol.* 2005 Jul;49(3):313-8.

[13] Elliott R. Executive functions and their disorders: Imaging in clinical neuroscience. *British Medical Bulletin.* 2003 Mar 1;65(1):49-59.

[14] M Marsel Mesulam. Aphasia, memory loss and other focal cerebral disorders. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson JL, editors. Harrison's Principles of Internal Medicine. 16 ed. New York: Mc-Graw Hill Medical publishing division; 2005; 151-2.

[15] Monsell S. Task switching. Trends in cognitive sciences 2003 Mar;7(3):134-40.

[16] Kleen JK, Sitomer MT, Killeen PR, Conrad CD. Chronic stress impairs spatial memory and motivation for reward without disrupting motor ability and motivation to explore. *Behav Neurosci.* 2006 Aug;120(4):842-51.

[17] Ohman L, Nordin S, Bergdahl J, Slunga BL, Stigsdotter NA. Cognitive function in outpatients with perceived chronic stress. *Scand J Work Environ Health.* 2007 Jun; 33(3): 223-32.

[18] Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav.* 1983 Dec;24(4):385-96.

[19] Lezak MD, Howieson DB, Loring DW. Orientation and attention. Neuropsychological assessment. 4 ed. New York: Oxford University Press; 2004; 337-74.

[20] Madanmohan, Udupa K, Bhavanani AB, Vijayalakshmi P, Surendiran A. Effect of slow and fast pranayams on reaction time and cardiorespiratory variables. *Indian J Physiol Pharmacol.* 2005 Jul;49(3):313-8.

[21] Gitananda Swami. Pranayama: The fourth limb of Ashtanga yoga. Satya press; 2008.

[22] Taylor AG, Goehler LE, Galper DI, Innes KE, Bourguignon C. Top-down and bottom-up mechanisms in mind-body medicine: development of an integrative framework for psychophysiological research. Explore (NY) 2010 Jan;6(1):29-41.

[23] Jella SA, Shannahoff-Khalsa DS. The effects of unilateral forced nostril breathing on cognitive performance. *Int J Neurosci.* 1993 Nov; 73(1-2):61-8.

[24] Joshi M, Telles S. Immediate effects of right and left nostril breathing on verbal and spatial scores. *Indian J Physiol Pharmacol.* 2008 Apr;52(2):197-200.

[25] Telles S, Raghuraj P, Maharana S, Nagendra HR. Immediate effect of three yoga breathing techniques on performance on a letter-cancellation task. *Percept Mot Skills.* 2007 Jun;104(3 Pt 2):1289-96.

[26] Brown RP, Gerbarg PL. Sudarshan Kriya yogic breathing in the treatment of stress, anxiety, and depression: part I-neurophysiologic model. *J Altern Complement Med.* 2005 Feb;11(1):189-201.

[27] Jerath R, Edry JW, Barnes VA, Jerath V. Physiology of long pranayamic breathing: neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. *Med Hypotheses.* 2006; 67(3):566-71.

[28] Telles S. Alterations of auditory middle latency evoked potentials during yogic consciously regulated breathing and attentive state of mind. 1993 May.

[29] Sharma Vivek, Trakroo Madanmohan, Subramaniam Velkumary, Rajajeyakumar M, Bhavanani Anand, Sahai Ajit. Academic journal article. *Int J Yoga.* 2013;6:104-10.

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Physiology, JIPMER, Puducherry, India.
2. Assistant Professor, Department of Physiology, Chennai Medical College Hospital & Research Centre, Irungalur, Trichy, Tamilnadu, India.
3. Assistant Professor, Department of Physiology, JIPMER, Pondicherry, India.
4. Senior Resident, Department of Physiology, JIPMER, Pondicherry, India.
5. Deputy Director, CYTER, Mahatma Gandhi Medical College and Research Institute, Puducherry, India.
6. Professor and Head, Department of Physiology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India.
7. Professor & Head, Department of Biostatistics, JIPMER, India.
8. Assistant Professor, Department of Physiology, Vinayaka Mission's Medical College & Hospital, Keezhakasakudi, Karaikal, Puducherry, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Senthil Kumar Subramanian,
Senior Resident, Department of Physiology, Jawaharlal Institute of Post-Graduate
Medical Education and Research, Pondicherry-605 006, India.
Phone: 91+ 9962267560, E-mail: drsenthilkumar83@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Aug 04, 2013**
Date of Peer Review: **Sep 10, 2013**
Date of Acceptance: **Oct 28, 2013**
Date of Publishing: **Jan 12, 2014**