



Effects of alternate nostril breathing exercise on cardiac functions in healthy young adults leading a stressful lifestyle

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ABSTRACT

Alternate nostril breathing (ANB) is one of the best and easiest breathing exercises. ANB exercise has beneficial effects on cardiac function in healthy and diseased people. The objectives of this study were to assess the effects of ANB exercise on cardiac physiology among healthy medical students. This was a prospective interventional study that was conducted in the Department of Physiology, Chittagong Medical College (CMC), Chattogram, Bangladesh, from July 2017 to June 2018. A total of 100 research participants (RPs) aged 18–20 years, Year-I medical students of CMC, were selected. A simple random sampling method was adopted. The selection was done after the inclusion and exclusion criteria were applied. The age and body mass index (BMI) of the RPs were analogous in both the control and experimental groups. Cardiac parameters, like pulse and blood pressure (BP), were measured. The initial baseline data were recorded for both groups and after 4 weeks. The research respondents of the experimental group performed ANB exercise for 4 weeks. The mean value pulse and BP were significantly ($p < 0.001$) changed after breathing exercise, compared to the values before the breathing exercise. The results of this study suggest that cardiac function significantly improves after the breathing exercise. Therefore, ANB can be recommended for increasing cardiac efficiency.

Keywords: *alternate nostril, nose, breathing exercise, ANB, cardiac function, healthy young adults, Chattogram Medical College, CMC*

Global health-related issues have been significantly changed in the last 100 years because of changes in lifestyles to cope with the new social order. Then, stress became a major cause of multiple noncommunicable diseases around the world that increases both morbidity and mortality by minimizing the quality of life.¹⁻⁴ In Bangladesh, around 20% of the adult population are suffering from cardiac disorders, especially hypertension.⁵ Good health status, both physiological and psychological, is dependent, to a great extent, on good cardiac performance. In addition, good lifestyle habits, especially regular yoga practice, maintain a high quality of health.^{2,6} Preventive, curative, and promotive health practices have been much advocated to achieve optimum health status.⁷ The breathing function is one that is possible to consciously control among all the autonomic functions and is widely accepted as a promising method to ensure health and fitness.^{8,9} It provides more oxygen, and emits out carbon-di-oxide and other toxic gaseous substances.⁹ Controlled breathing channels the sympathetic and parasympathetic physiologic functions toward a harmonic state.⁸ Multiple earlier studies reported that alternate nostril breathing (ANB) modulated the sympathovagal balance to augment better-quality cardiac function.^{4,8-10} ANB also relieved stress,¹¹⁻¹³ refined metabolism,¹⁴⁻²⁰ improved cognitive function,^{11,21-23} and delayed the normal aging process.^{24,25} Breathing exercises are often called pranayama in Indian yoga-related manuscripts.¹⁰ Yoga is a psycho-somatic spiritual performance that frequently achieves, merges, and harmonizes between the mind, body, and soul² and has been widely practiced in the Indian subcontinent for over thousands of years.¹⁰ Yoga gained importance and became increasingly accepted as an overall health improvement tool in the Western society.^{26,27} Thereafter, the United Nations General Assembly in 2015 declared June 21 as the “International Yoga Day”.²⁸

Different types of breathing exercises that include deep breathing, inhalation–retention–exhalation at fixed intervals, abdominal/diaphragmatic breathing, and ANB/Anuloma Viloma were practiced in different disciplines.⁷ ANB is one of the easiest and the best breathing exercises.⁹ In addition, it is cost-effective, as it does not require any special equipment or definitive time.⁹ ANB completely rejuvenates and energizes the physiological process that includes both the physical and the psychological domains.^{2,9} In ANB exercise, slow inhalation followed by slow exhalation of air through one nostril is practiced keeping the alternate nostril closed with a short interval of breath-holding in between inhalation and exhalation.²⁹ The burden of the medical curriculum frequently imposes extreme study-related stress on the medical student.^{4,30} Subsequently, continuous stress recurrently leads to irritability, insomnia, anxiety, and depression.⁴ Stress even changes the set point of the hypothalamic–pituitary axis, leading to sympathovagal imbalance.⁸ Stress has immediate harmful effects on the cardiovascular system. Hence, cardiovascular disease is often prevalent among these individuals.⁸ Multiple studies revealed that deep breathing exercise significantly decreased salivary cortisol concentration, and thereby blood pressure (BP); had a neuroprotective effect; increased skill, memory with decreased anxiety; improved cognitive functions and the lipid profile among high-risk patients of dyslipidemia.^{11,12,18-20,21-23} In previous studies, breathing exercise revealed that it improved significantly both heart rate (HR) and BP among healthy and poor cardiovascular performers by minimizing stress.^{4, 8,30-33} Breathing exercise resets the autonomic nervous system with decreased adrenalin-mediated sympathetic activity and thereby peripheral resistance, HR, and BP.^{8,31-34} ANB was used effectively for preventive and therapeutic purposes, either alone or in combination with pharmacological

interventions.² Regular practicing of ANB has been reported to produce positive cardiovascular system impact by preventing the onset of multiple cardiovascular disease and progression.² This study was conducted to assess the physiological effects of short-term ANB exercise on cardiac function among healthy medical students.

MATERIALS AND METHODS

Study Design

This research work was an experimental study. It was conducted in the Department of Physiology, CMC, Chattogram, Bangladesh, from July 2017 to June 2018. A total of 100 research participants (RPs) were recruited for this study, with 50 members each in the control and experimental groups, respectively. RPs were Year-I medical students of CMC, aged 18–20 years, with a BMI of 18.5–22.9 kg/m², enrolled in the study with informed consent. Simple random sampling by lottery method was adopted to select all the RPs.

To determine the sample size for this study, the following formula was used:^{35,36}

$$n = 2 \left[\frac{(Z\alpha + Z\beta)\sigma}{\mu_1 - \mu_2} \right]^2$$

n = the desired sample

Z_α = Z value of the standard normal deviate set at 1.96 that corresponds to the 95% confidence interval

Z_β = Z value of standard normal deviate at 80% power

σ = The standard deviation of the population (from the previous study)³⁷

μ_1 = Expected control group mean (from the previous study) (37)

μ_2 = Expected experimental group mean (from the previous study) (37)

Here,

$$Z_\alpha = 1.96, Z_\beta = 0.84, \sigma = 8.46, \mu_1 = 85.70, \mu_2 = 90.43$$

$$n = 2 \left[\frac{(1.96 + 0.84)8.46}{85.70 - 90.43} \right]^2 = 50$$

Thereby, 50 students in the control and experimental groups were selected as study subjects. Ten students dropped out during the study. Ten percent of extra students (total 110) were taken to mitigate the dropping out of the subjects.

Sample Inclusion Criteria

The Year-I medical students of CMC, Chattogram, aged between 18 and 20 years, having a BMI of 18.5–22.9 kg/m², and fulfilling the inclusion and exclusion criteria, were enrolled in the study with informed consent. Detailed personal information, medical and family history, and the history of physical activity status were recorded in a pre-determined questionnaire from all the RPs who participated voluntarily. The RPs, who previously did not perform breathing exercises, were randomly selected.

Sample Exclusion Criteria

RPs with a previous history of cardiovascular disease, respiratory illness, any nasal pathology, and smoking, and those receiving respiratory depressant drugs, and those with vertebral deformities were excluded from the study.

Project Details

Age, height, body weight, and the BMI of the RPs were recorded in a predesigned case record form. BMI was calculated by the formula, BMI = Weight in Kg/height in m². Cardiac parameters (pulse and BP) of students were recorded in an upright sitting posture before commencing breathing exercises to see the baseline parameters in both the control and experimental groups. The

control group RPs were neither trained nor allowed to practice ANB, and the experimental group RPs were taught detailed steps of ANB with audiovisual demonstration, and they practiced ANB daily 10 min during the college period for 4 weeks. Radial pulse was counted for a minute keeping the subject's forearm slightly pronated. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in the sitting position in the left arm of each subject by a palpatory and auscultatory method with the help of a stethoscope and aneroid sphygmomanometer after proper exposure (ALPK2, Japan). RPs were asked to remain in the sitting posture for 15 min to become mentally and physically relaxed and free from excitation and anticipation. Three consecutive readings from pulse and BP measurement procedures were taken, and the best value was recorded. Then, the experimental group practiced ANB exercise daily for 10 min for 4 weeks. After 4 weeks, cardiac parameters were again measured in both the control and experimental groups.³⁸

Data Collection Details

Detailed personal information, medical and family history, and the history of physical activity status were recorded in a pre-determined questionnaire from all the RPs who participated voluntarily.

Statistical Analysis

All the data were compiled and processed after collection. Results were expressed as mean \pm SD (standard deviation) and range. Pulse and BP records were analyzed by the independent *t*-test in SPSS-23 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). A paired-sample *t*-test compared between pre- and post-intervention data and unpaired *t*-test compared between the groups for statistical analysis. 95% confidence limit was taken as a minimum level of significance. In the interpretation of results, $p < 0.05$ was accepted as the level of significance.

Ethical Approval

The protocol of this study was approved by the members of the Ethical Review Board (ERB) of CMC, Chattogram, and received a certificate of ethical clearance of ERB [Reference No.: CMC/PG/2018/403; dated 10/5/2018].

RESULTS

In this study, all experimental RPs were like healthy control by age, height, weight, and BMI. In this study, at baseline, pulse, SBP, and DBP between the control and experimental groups at the beginning of the study showed no significant difference (Table 1). Again, significant decrement ($p < 0.001$) was observed in all these cardiac



FIG 1. Steps of ANB. (a) The RPs were asked to close the left nostril with the thumb of the left hand and inhale through the right nostril for 6 sec. (b) Then, they closed the right nostril by the index finger and held the breath for 6 sec. (c) Then, they exhaled through the left nostril slowly for 6 sec. (d) Then, they inhaled through the left nostril, keeping the right nostril closed for 6 sec. (e) Then, the RPs hold the breath, closing both nostrils for 6 sec. (f) Then, they exhaled through the right nostril, keeping the left closed for 6 sec.³⁸

TABLE 1. Comparison of Cardiac Parameters between the Control (without ANB Exercise) and Experimental Groups (with ANB Exercise) at the Beginning and at the End of the Study (n = 100)

Cardiac attributes		Pulse (beats/min) Mean \pm SD (range)	SBP (mm of Hg) Mean \pm SD (range)	DBP (mm of Hg) Mean \pm SD (range)
At the beginning of study	Control group (n = 50)	78.76 \pm 1.890 (74–86)	116.00 \pm 4.949 (110–120)	75.40 \pm 5.425 (60–80)
	Experimental group (n = 50)	78.92 \pm 1.904 (72–84)	115.80 \pm 4.986 (110–120)	74.20 \pm 6.091 (60–80)
	p-value (t-value)	0.667 ns (0.433)	0.844 ns (0.198)	0.278ns (1.098)
At the end of study	Control group (n = 50)	79.32 \pm 2.478 (68–82)	117.40 \pm 4.431 (110–120)	76.30 \pm 5.230 (60–80)
	Experimental group (n = 50)	72.72 \pm 4.329 (62–80)	103.40 \pm 6.884 (90–110)	68.36 \pm 6.574 (60–80)
	p-value (t-value)	<0.001** (9.423)	<0.001** (12.537)	<0.001** (7.394)

Data expressed as mean \pm SD, ANB = alternate nostril breathing, SBP = systolic blood pressure, DBP = diastolic blood pressure, SD = standard deviation; Figures in parenthesis indicate range, statistical analysis done by Student's unpaired t-test, ns = not significant, ** = statistically significant test ($p < 0.001$).

parameters between the control and experimental groups at the end of the study (Table 2).

After 4 weeks' follow-up, the experimental group with ANB exercise experienced a significant decrease in their pulse, SBP, and DBP ($p < 0.001$) when compared to their baseline values, whereas after 4 weeks the control group, which had no exposure to ANB, did not experience any significant changes in the above-mentioned parameters (Table 2 and Figures 2, 3).

DISCUSSION

This study assessed cardiac functions in the experimental group before and after ANB exercise for 4 weeks by analysis of pulse, SBP, and DBP, and compared these results with the control group. In this study, in the control group, the pulse rate, SBP, and DBP were observed. The mean pulse rate, SBP, DBP in the control group before and after 1 month without practicing ANB did not show any change. Although these parameters were a bit higher than the

previous values, they were insignificant. In the experimental group, cardiac parameters (pulse rate, SBP, and DBP) before and after ANB for 1 month were significantly decreased. Previous investigators also reported similar findings.^{2,4,8,29–31,39–43} The results of this study were identical with the conclusions from Biswas et al.² Pal et al.⁴ and other investigators. They supposed that breathing exercises might increase parasympathetic activity and decrease sympathetic activity. This might cause a decrease in pulse rate and BP.^{2,44}

During breathing exercise, attention on the act of breathing removes focus from worldly worries and de-stresses a person.^{38,41,45} This may decrease the release of adrenaline and reduce BP, which was explained by Gupta et al.⁴⁵ and Dhungel et al.³⁹ Breathing exercise alters the hypothalamic discharge, leading to a decrease in sympathetic tone and peripheral resistance. Hence, the DBP was decreased. Increase in vagal tone reduces the workload on the heart and thus decreases CO and

TABLE 2. Comparison of Cardiac Parameters between the Beginning and the End of the Study in the Control (without ANB Exercise) and Experimental Groups (with ANB Exercise) (n = 100)

Cardiac attributes		Pulse (beats/min) Mean ± SD (range)	SBP (mm of Hg) Mean ± SD (range)	DBP (mm of Hg) Mean ± SD (range)
Control group (n = 50)	At the beginning of study	78.76 ± 1.890 (74–86)	116.00 ± 4.949 (110–120)	75.40 ± 5.425 (60–80)
	At the end of study	79.32 ± 2.478 (68–82)	117.40 ± 4.431 (110–120)	76.30 ± 5.230 (60–80)
	p-value (t-value)	0.159 ns (1.429)	0.181 ns (1.358)	0.441 ns (0.777)
Experimental group (n = 50)	At the beginning of study	78.92 ± 1.904 (72–84)	115.80 ± 4.986 (110–120)	74.20 ± 6.091 (60–80)
	At the end of study	72.72 ± 4.329 (62–80)	103.40 ± 6.884 (90–110)	68.36 ± 6.574 (60–80)
	p-value (t-value)	<0.001** (11.616)	<0.001** (12.246)	<0.001** (5.496)

Data expressed as Mean ± SD, ANB = alternate nostril breathing, SBP = systolic blood pressure, DBP = diastolic blood pressure, SD = standard deviation; Numbers in parenthesis indicate range, statistical analysis done by Student's paired t-test, ns = not significant ($p > 0.05$), ** = statistically significant test ($p < 0.001$).

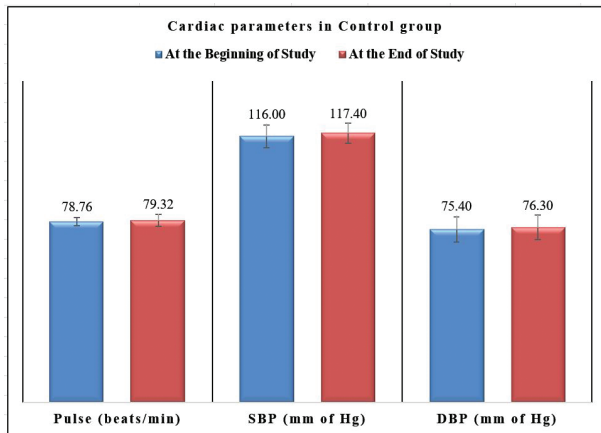


FIG 2. Cardiac Parameters in the Control Group (without ANB Exercise) at the Beginning and End of the Study.

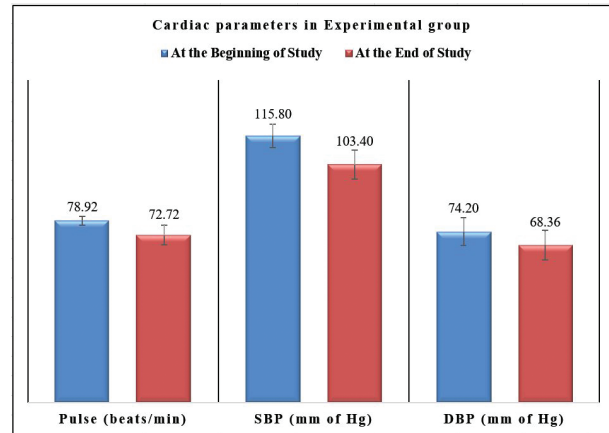


FIG 3. Cardiac Parameters in the Experimental Group (with ANB exercise) at the Beginning and End of the study.

thereby SBP.⁴¹ Regular practice of rhythmic slow breathing has been shown to increase baroreflex sensitivity activation and thus reduce SBP and DBP in hypertensive patients.⁴⁶ Possibly, the above mechanisms were also responsible for the

reduction in the cardiac parameters in this study. Some investigators found no significant changes in SBP and DBP after breathing exercise practice, which is dissimilar with the current research.⁴⁷ It was explained in earlier researches that RPs were

normotensive due to the short period of study.⁴⁷ ANB exercise brought about a significant decrement in cardiac parameters (pulse, BP) in the experimental group of medical students. Therefore, ANB is very much helpful for the improvement of cardiac function as well as the prevention of different complications of cardiac problems.

This study was conducted for both academic and clinical purposes in a short period of time. Although optimal care was taken by the researcher in every step of the study, there were some limitations: (1) short period of study, (2) small sample size that might not represent the whole community, (3) study conducted with a limited age group, (4) study conducted only on Year-I medical students, (5) a socio-demographic study not conducted, (6) proper sitting posture in the floor on the mat was not maintained and (7) catecholamine level in the blood and urinary excretion were not measured to observe the stress pattern.

CONCLUSION

In the present study, yoga-based ANB exercise for 1 month brought about significant improvement in the cardiac parameters (pulse and BP) in the RPs. Although, it was difficult to comment on the exact mechanism involved here, probably it was due to the shifting of the sympathovagal balance toward parasympathetic predominance. Therefore, this study concludes that the regular performance of ANB can be a useful measure for the improvement of cardiac endurance and functions. This may help in preventing different complications of cardiac problems in the future. As this procedure requires no instrument, is a straightforward technique to adopt, and a cost-effective phenomenon, popularization of this activity will ultimately be helpful in increasing the longevity of human beings.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

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DATA AVAILABILITY STATEMENT

The data will be available only for research purpose.

COMPLIANCE WITH ETHICAL STANDARDS

This study was approved by the Chittagong Medical College, Institutional Review Board, Chattogram, Bangladesh.

REFERENCES

1. Sharma KK, Udayakumara K, Thirmaleshwara PH, Ajithesha NH. Effect of yoga therapy on lung functions in respiratory disorder subjects. *Euro Sci J*. 2014;10(6):102–8.
2. Biswas S, Biswas P, Sayyad R, Eliyaraju A, Yadav PK, Kar SK. Effect of forty days of pranayama training on cardiorespiratory parameters. *Indian J Basic Appl Med Res*. 2014;3(4):196–202.
3. Murray CJL, Lopez AD. The Global burden of disease: A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. [cited 2019 Feb 11]. Available from: <https://apps.who.int/iris/handle/10665/41864>

4. Pal GK, Agarwal A, Karthik S, Pal P, Nanda N. Slow yogic breathing through right and left nostril influences sympathovagal balance, heart rate variability, and cardiovascular risks in young adults. *N Am J Med Sci.* 2014;6(3):145–51. <https://doi.org/10.4103/1947-2714.128477>
5. Koly KN, Biswas T, Islam A. Increasing prevalence of hypertension in Bangladesh: A review. *Cardiovasc J.* 2015;8(1):59–64. <https://doi.org/10.3329/cardio.v8i1.24771>
6. Doijad VP, Kamble P, Surdi AD. Effect of yogic exercises on aerobic capacity. *Int J Recent Trend Tech.* 2013;6(3):119–21. <https://doi.org/10.5958/j.2320-608X.1.2.010>
7. Yadav RK, Das S. Effect of yogic practice on pulmonary functions in young females. *Indian J Physiol Pharmacol.* 2001;45(4):493–6.
8. Chethan K, Devaraju MR. A study on effect of nadi-shodhana pranayama on cardiac parameters. *Indian J Basic Appl Med Res.* 2016; 6(1):484–7.
9. Bal BS. Impact of short-term training of Anulom Vilom (Alternate nostril breathing) on respiratory parameters. *Am J Sports Sci Med.* 2015;3(1):9–14. <https://doi.org/10.269/ajssm-3-1-2>
10. Chakraborti T, Das K, Samajdar K. Effect of yogic exercise on selected pulmonary function tests in apparently healthy elderly subjects. *IOSR J Dent Med Sci.* 2013;9(1):1–5. <https://doi.org/10.9790/0853-0910105>
11. Ma X, Yue ZQ, Gong ZQ, Zhang H, Zhang H, Duan NY, et al. The effect of diaphragmatic breathing on attention, negative affect, and stress in healthy adults. *Front Psychol.* 2017;8(1):1–12. <https://doi.org/10.3389/fpsyg.2017.00874>
12. Singh S, Katwal B, Panta PP. Slow and deep breathing exercise (Pranayama) for a stress-free life amongst medical students. *Int J Res Rev.* 2017;4(7):67–72.
13. Nail GS, Gaur GS, Pal GK. Effect of modified slow breathing exercise on perceived stress and basal cardiovascular parameters. *Int J Yoga.* 2018;11(1):1–14. https://doi.org/10.4103/ijoy.IJOY_41_16
14. Tells S, Nagarathna R, Nagendra R. Breathing through a particular nostril can alter metabolism and autonomic activities. *Indian J Physiol Pharmacol.* 1994;38(2):133–7.
15. Young MS, Lee YS, Lee HY. Effects of breathing exercise on resting metabolic rate and maximal oxygen uptake. *J Phys Ther Sci.* 2018;30(1):1173–5. <https://doi.org/10.1589/jpts.30.1173>
16. Shende V, Waghmore S, Pawar S, Kashaliker S. Effect of pranayama on blood glucose level in medical students: A case-control study. *Int J Res Health Sci.* 2013;1(3):209–12.
17. Manjunatha S, Vempati RP, Ghosh RD, Bijlani RD. An investigation into the acute and long-term effects of selected yogic postures on fasting and postprandial glycemia and insulinemia in healthy young subjects. *Indian J Physiol Pharmacol.* 2005;49(3):319–24.
18. Surendra BV, Hariprasad T. Effect of pranayama and yogasanas on lipid profile in normal healthy volunteers. *Int J Clin Biomed Res.* 2016;2(3):13–16.
19. Chanda R, Sanjjev R, Rahul V, Mahapatra SP. Biochemical modulation in regular practice of yoga in young, healthy medical students. *World J Pharm Pharm Sci.* 2017;6(2):617–28. <https://doi.org/10.20959/wjpps201712-10520>
20. Shantakumari N, Sequeira S, Deeb RE. Effects of yoga intervention on lipid profiles of diabetes patients with dyslipidemia. *Indian Heart J.* 2013;65(1):127–31. <https://doi.org/10.1016/j.ihj.2013.02.010>
21. Villemure C, Ceko M, Cotton VA, Bushnell MC. Neuroprotective effects of yoga practice: Age, experience, and frequency-dependent plasticity. *Front Hum Neurosci.* 2015;9(2):1–12. <https://doi.org/10.3389/fnhum.2015.00281>
22. Subramanya P, Telles S. Effect of two yoga-based relaxation techniques on memory scores and state anxiety. *Biopsychosoc Med.* 2009;1(1):1–5. <https://doi.org/10.1186/1751-0759-3-8>
23. Yadav G, Mutha PK. Deep breathing practice facilitates retention of newly learned motor skills. *Nat Sci Rep.* 2016;1(2):1–8. <https://doi.org/10.1038/srep37069>
24. Berri K. Breathing to younger skin: “Reversing the molecular mechanism of skin aging with

- yoga.” *Future Sci OA*. 2016;2(2):10–24. <https://doi.org/10.4155/fsoa-2016-0015>
25. Sharma H, Datta P, Singh A, Sen S, Bhardwaj NK, Kochupillai V, et al. Gene expression profiling in practitioners of Sudarshan Kriya. *J Psychosom Res*. 2008;64(1):213–8. <https://doi.org/10.1016/j.jpsychores.2007.07.003>
 26. Subhalakshmi NK, Saxena SK, Urmimala S, Urban JAD. Immediate effect of nadishodhana pranayama on some selected parameters of cardiovascular, pulmonary, and higher functions of brain. *Thai J Phys Sci*. 2005;18(2):10–16.
 27. Kurmur KA, Joshi VS, Maulik S, Padlia JL, Sarvaiya JL. Effect of ten weeks’ yoga practice on pulmonary function tests. *Int J Biomed Adv Res*. 2015;6(9):682–5. doi:10.439/ijbar
 28. Agarwal D, Gupta PP, Sood S. Assessment for efficacy of additional breathing exercises over improvement in health impairment due to asthma assessment using St. George’s respiratory questionnaire. *Int J Yoga*. 2017;10(3):145–51. <https://doi.org/10.4103/0973-6131.213472>
 29. Pal GK, Velkumary S, Madanmohan S. Effect of short-term practice of breathing exercises on autonomic functions in normal human volunteers. *Indian J Med Res*. 2004;120:115–21.
 30. Dhanvijay AD, Dhokne N, Choudhary AK, Kishanrao SS, Chandan L. Effects of alternate nostril breathing on cardiorespiratory variable in healthy young adults. *Int J Pharm Biol Sci*. 2015;6(2):1352–60.
 31. Satayanand V, Reddy B, Lilly N, Mahaboobvali S, Shaik AB, Aditya M. Studying the role of yogic pranayama in the management of blood pressure. *Int J Biomed Adv Res*. 2014;5(12):609–11.
 32. Chintamani DB, Bhavne SN, Jankar DS. Effects of short-term pranayama on certain cardiovascular risk factors. *Int J Biomed Res*. 2015;6(2):83–6. <https://doi.org/10.7439/ijbr.v6i2.1621>
 33. Yadav RC. Effects of twelve weeks selected pranayama practice on primary high blood pressure patients. *Eur J Pharm Med Res*. 2016;3(6):471–4.
 34. Satayanand V, Reddy B, Lilly N, Mahaboobvali S, Mohan D, Salma S, et al. Effect of yoga on hypertension. *Narayana Med J*. 2016;5(1):4–11.
 35. Dawson A, Beth H, Trapp RG. Research Questions About Two Separate or Independent Groups. In: *Basic and clinical biostatistics*, 4th ed. USA: McGraw-Hill. 2004; p 155.
 36. Hoque MM. Sample size calculation. *ABC of research methodology and biostatistics*. 2nd ed. Dhaka: ABC Publishers; 2014. p. 156.
 37. Mekonnen D, Mossie A. Clinical effects of yoga on asthmatic patients: A preliminary clinical trial. *Ethiop J Health Sci*. 2010;20(2):107–12. <https://doi.org/10.4314/ejhs.v20i2.69436>
 38. Jahan I, Begum M, Akhter S, Islam Z, Jahan N, Haque M. Effects of alternate nostril breathing exercise on respiratory functions in healthy young adults leading stressful lifestyle. *J Popul Ther Clin Pharmacol*. 2020;27(1):104–14. <https://doi.org/10.15586/jptcp.v27i1.668>
 39. Dhungel KU, Malhotra V, Sarkar D, Prajapati R. Effect of alternate nostril breathing exercise on cardiorespiratory functions. *Nepal Med Coll J*. 2008;10(1):25–7.
 40. Gupta V, Singh Y, Vikramaditya B, Singh H. Immediate effect of “Nadi-Shodhana Pranayam” on some selected parameters of cardiorespiratory and mental efficiency. *J Curr Trends Clin Med Laborat Biochem*. 2014;2(3):12–15.
 41. Shrivastava RD, Nidhi J, Singhal A. Influence of alternate nostril breathing on cardiorespiratory and autonomic functions in healthy young adults. *Indian J Physiol Pharmacol*. 2005;49(4):475–83.
 42. Singh S, Gaurav V, Parkash V. Effects of a 6-week nadi-shodhana pranayama training on cardio-pulmonary parameters. *J Phys Educ Sports Manage*. 2011;2(4):44–7.
 43. Telles S, Yadav A, Kumar N, Sharma S, Visweswaraiyah NK, Balkrishna A. Blood pressure and Purdue pegboard scores in individuals with hypertension after alternate nostril breathing, breath awareness, and no intervention. *Med Sci Monit*. 2013;19:61–6. <https://doi.org/10.12659/MSM.883743>
 44. Upadhyay-Dhungel K, Sohal A. Physiology of nostril breathing exercises and its probable relation with nostril and cerebral dominance: A theoretical research on literature. *Janaki Med Coll J*

- Med Sci. 2013;1(1):38–47. <https://doi.org/10.3126/jmcjms.v1i1.7885>
45. Gupta A, Gupta R, Sood S, Akram M. Pranayama for treatment of chronic obstructive pulmonary disease: Results from a randomized controlled trial. *Integr Med.* 2014;13(1):26–31.
46. Isac S, Indu KM. Effectiveness of breathing exercises on hypertension among patients with chronic renal failure. *Int J Med Health Prof Res.* 2016;3(1):25–30.
47. Tarunker AV, Jain S, Patel SB, Sinha SR, Joshi AD, Vallish BN, et al. Effects of slow breathing exercise on cardiovascular functions, pulmonary functions & galvanic skin resistance in healthy human volunteers-a pilot study. *Indian J Med Res.* 2013;137(5):916–21.