Chapter II

REVIEWS OF RELATED LITERATURE

Practice of Pranayama has been known to modulate cardiac autonomic status with an improvement in cardio-respiratory functions. Keeping this in view, the present study was designed.

Research has proved to be essential and powerful tool leading to progress. So there would have been very little progress without systematic research. One of the steps in systematic research is the review of related literature. Hence, some of the related studies from the literature are mentioned below:

Karambelkar, Deshpande & Bhole\(^1\) (1983) conducted a study to see the composition of expired air in Pranayamic breathing. The study was carried out on 11 healthy males in the age group of 22-35 who were well established in various Yoga techniques. Expired air was collected by open circuit method yoga technique. It was collected in completely evacuated rubber bags. Composition of expired air was studied in different conditions in five experimental designs. The oxygen and carbon dioxide percentage of expired air varies to great at the end of six rounds of Ujjayi and Bhashrika Pranayama having 1:2:2 ratios of Puraka, Kumbhaka and Rechaka, but different time units for one round viz., 30, 40 and 70 seconds.

Kalwale et. al.\(^2\) (2013) conducted a study to see the effect of different durations of Pranayama on cardio respiratory parameters. 80 healthy volunteers in the age group of 35-55 years were selected for the study. Group-I did pranayama practice for one hour daily for a duration of eight days. Group-II did the same pranayama for 1 hour daily for a duration of one month. In group-II, pranayama training produced a significant decrease in systolic blood pressure, the difference being statistically significant (p<0.05). On the other hand there was no significant change in systolic

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blood pressure in group-I. Pulse rate showed significant decrease in the group-II (p<0.01) whereas in the group-I, there was no significant change in pulse rate. Also there was significant decrease in body weight in group-II (p<0.001). On the other hand there was no significant change in the body weight in group-I. There was no significant change in diastolic blood pressure and respiratory rate in both groups. In conclusion, the study showed that one month of pranayama training produces a significant decrease in pulse rate and systolic blood pressure. The decrease in systolic blood pressure and pulse rate may have been brought about by increased parasympathetic and decreased sympathetic activity.

Bal $^3$ (2010) conducted a study to see the effect of Anuloma Viloma and Bhasilrika Pranayama on the vital capacity and maximal ventilatory volume. 30 randomly selected male students aged 18 - 26 years volunteer participated in the study from D.A.V. Institute of Engineering and Technology, Jalandhar (Punjab), India. They were randomly assigned into two groups i.e. A (experimental) and B (control). The subjects were subjected to eight weeks Pranayama training program that included “Anuloma-Viloma and Bhasilrika Pranayama”. The between-group differences were assessed using the Student’s t-test for dependent data. The level of significance was considered at 0.05. The vital capacity and maximal ventilatory volume significantly improved in group-A as compared with the control group. Pranayama training program might be recommended to improve vital capacity and maximal ventilatory volume.

Shukla $^4$ (2009) conducted a study to see the efficacy of Nostril dominance Yogic practices on Cardio-respiratory parameters of Badminton players. 21 male Badminton players ranging between 17-22 years were randomly selected as subjects from Guru Gobind Singh Sports College, Lucknow and were grouped into three experimental groups (A, B & C) i.e. left nostril dominance group, right nostril dominance group and uni-nostril dominance group respectively and each group consisted of 7 subjects was measured on peak flow rate, vital capacity, cardio respiratory, heart rate and respiratory rate. The three experimental groups participated.


in a 3 week, 4 days a week for 50 minutes of duration in their respective yogic training program. Paired t test was used to analyze the data on selected parameters at 0.05 level of significance. The obtained t- value of left nostril dominance experimental group, right nostril experimental group and uni-nostril dominance experimental group on Peak flow rate, vital capacity, cardio-respiratory endurance, heart rate and respiratory rate were significant.

Kaushik et. al.\(^5\) (2012) conducted a study to see the improvement in ventilatory function through yogic practices. 60 healthy male volunteers (age ranging 21–33 years and height of 174.8 ± 3.52 cm) drawn randomly from BSF personnel participated in the study. Participants practiced Yoga under the supervision of professional Yoga instructor two hours daily for five days a week, along with their daily routine activities. Standing height, weight and dynamic lung function tests viz. Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1) and Maximum Voluntary Ventilation (MVV) were measured before and after two months of yoga training. Tiffeneau index (TI) was calculated before and after the said training. After two months of yogic practice, there was no significant change in body weight with a trend of reduction. MVV increased significantly (P< 0.01) while the other parameters viz. FVC, FEV1 and TI did not change significantly. Increase in MVV indicated that Yogic practices improved the pulmonary capacity of practitioner which could help in enhancement of ventilatory functions.

Gajalakshmi & Ravindran\(^6\) (2012) conducted a study to see the effect of Pranayama on autonomic and pulmonary functions. 50 healthy volunteers (26 male and 24 female) were selected for the study. All the volunteers were divided equally in two groups which served as control and treatment group. Individuals of treatment group practiced Pranayama daily in the morning from 7.00 to 7.30 AM for 12 weeks. Baseline parameters were recorded before and after treatment application and data were analyzed by using one-way ANOVA. Results showed significant increase in Vital Capacity (VC), Peak Expiratory Flow Rate (PEFR), Tidal Volume (TV), prolongation of Breath Holding Time (BHT), 40 mmHg endurance tests and parasympathetic reactivity (valsalva maneuver). Significant decrease was found in


sympathetic reactivity (Cold Pressor Test-CPT), whereas Maximum Ventilatory Volume (MVV), Inspiratory Reserve Volume (IRV) and Expiratory Reserve Volume (ERV) did not show any significant change.

Sivapriya et al. (2010) conducted a study to evaluate the effects of Nadi Shodhana on respiratory parameters i.e. peak expiratory flow rate (PEFR), forced vital capacity (FVC), forced expiratory volume in 1 sec (FEV1) and respiratory rate (RR) in school students of both sexes. 115 school students aged between 8 – 14 years studying in Visa Nursery & Primary School, Chennai were selected as the subjects for the study. The participants were trained to perform Nadi Shodhana Pranayama and the study was carried out for 45 days. The respiratory parameters PEFR, FVC, FEV1 & RR, were measured before and after practice of Pranayama. The results of the study showed significant increase in PEFR, FVC & FEV1. The RR declined after the practice of Nadi Shodhana Pranayama.

Sodhi et al. (2009) conducted a study to see the effect of Yoga training on pulmonary functions in patients with Bronchial Asthma. 120 patients of asthma were randomized into two groups i.e. Group A (yoga training group) and Group B (control group). Each group included sixty patients. Pulmonary function tests were conducted on all the patients at baseline, after 4 and then after 8 weeks. Majority of the subjects in the two groups had mild disease (34 patients in Group A and 32 in Group B). Group A showed a significant increasing trend (P<0.01) in % predicted peak expiratory flow rate (PEFR), forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), forced mid expiratory flow in 0.25–0.75 seconds (FEF25-75) and FEV1/FVC% ratio in 4 and 8 weeks as compared to Group B. Thus, yoga breathing exercises used adjunctively with standard pharmacological treatment significantly improves pulmonary functions in patients with bronchial asthma.

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Upadhyay et. al.\(^9\) (2008) conducted a study to see the effect of alternate nostril breathing exercise on cardio respiratory functions. The responses of Alternate Nostril Breathing (ANB) (\textit{Nadisudhi}) on selected cardio-respiratory functions were investigated in healthy young adults. The subjects performed ANB exercise (15 minutes, everyday in the morning) for four weeks. Cardio-respiratory parameters were recorded before and after 4-week training period. A significant increase in Peak Expiratory Flow Rate (PEFR L/min) and Pulse pressure (PP) was noted. Although systolic blood pressure (SBP) was insignificant, whereas pulse rate (PR), respiratory rate (RR) and diastolic blood pressure (DBP) were significant. Results indicated that regular practice of ANB (\textit{Nadisudhi}) increased parasympathetic activity.

Shivraj et. al.\(^10\) (2008) conducted a study to see the effect of selected breathing techniques on respiratory rate and breathe holding time in healthy adults. The study was conducted in the department of Physiology, Seth G.S. Medical College and K.E.M. Hospital, Mumbai. 90 male and female participants were selected for the study and they were divided into control and experimental groups with 45 members each of both the sexes at the age group of 20±2 years. The experimental group was asked to perform Kapalbhati, Anuloma-Viloma, Bhramari and Udegeeth Pranayama. The duration of the study was 8 week. The respiratory rate and breath holding time in both the groups were recorded and analyzed by using student’s t-test and level of significance was set at 0.05. In experimental group, the respiratory rate decreased significantly (p=0.000) whereas the breath holding time was increased significantly (p=0.000) when compared to control group.

Prakasamma & Bhaduri\(^11\) (1984) conducted a study to see the Yoga as a nursing intervention in the care of patients with pleural effusion. 10 patients, with pleural effusion, practiced alternate nostril breathing for 20 days after aspiration of fluid. An equal number matched for age and smoking habits underwent routine physiotherapy in hospital for the same period. Lung function was measured before aspiration, immediately after aspiration and after another 5, 10, 15 and 20 day. The


FVC, FEV, MVV, PEFR, CE and RS were selected to measure lung function. The difference between the two groups, in the gain in lung expansion as assessed by the above measures, was tested for significance with appropriate non-parametric statistical tests at 0.01 level of significance. The results revealed that the patients practicing Pranayama demonstrated a quicker re-expansion of the lungs in most of the measures of lung function.

Mamtha\textsuperscript{12} (2008) conducted a study to see the effect of Pranav, Nadishuddhi and Savitri Pranayama practice on pulmonary function test and breathe holding time. The study was undertaken to assess the effects of Pranayama practice on pulmonary functions in adults in the age group of 18 – 28 years. 20 Male students of Ramakrishna Institute of Moral and Spiritual Centre (RIMS), Mysore and 20 female students of JSS Polytechnic College formed the experimental group. 20 male students and 20 female students of JSS Medical College were taken as Control group. Pulmonary Function Tests (PFT) was measured by Medspiror and Breath Holding Time (BHT) was measured by Mercury Manometer. Both in experimental group and control group first phase of recording was taken at the starting of their curriculum and second phase of recording was registered after 24 weeks. The experimental group showed significant increase in pulmonary function test values i.e. FVC, FEV\textsubscript{1}, FEV\textsubscript{3}, PEFR, MVV and BHT, but there was no significant change in the above parameters in the control group. PFT values were higher in experimental group. This might be due to regular deep inspiration and expiration during Pranayama practice leading to the strengthening of respiratory muscles. The increase in BHT was due to acclimatization of chemoreceptors to the increased concentration of CO\textsubscript{2} gradually by regular practice of Pranayama.

Ankad et. al.\textsuperscript{13} (2011) conducted a study to ascertain a short-term practice of Pranayama and Meditation had improvements in cardiovascular functions in healthy individuals with respect to age, gender, and body mass index (BMI). This interventional study was conducted in the Department of Physiology, S.N. Medical


College, Bagalkot. 50 healthy subjects (24 males and 26 females) of 20–60 years of age group, fulfilling the inclusion and exclusion criteria underwent two hours daily Yoga program for 15 days taught by a certified yoga teacher. Pre and post yoga cardiovascular functions were assessed by recording pulse rate, systolic blood pressure, diastolic blood pressure, and mean blood pressure. The parameters were analyzed by Student's $t$-test. There was significant reduction in resting pulse rate, systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure after practicing Pranayama and Meditation for 15 days. The response was similar in both the genders, both the age groups, <40 yrs and >40 yrs and both the groups with BMI, <25 kg/m$^2$ and >25 kg/m$^2$. This study showed beneficial effects of short term (15 days) regular Pranayama and Meditation practice on cardiovascular functions irrespective of age, gender, and BMI in normal healthy individuals.

Veerabhadrappa et. al.\textsuperscript{14} (2011) conducted a study to see the effect of Yogic bellows on cardiovascular autonomic reactivity. The objective of the study was to evaluate the effect of long-term practice of fast Pranayama (\textit{Mukh Bhasrika}) on autonomic balance on individuals with stable cardiac function. 50 healthy male subjects of 18 - 25 years of age group, fulfilling the inclusion and exclusion criteria underwent \textit{Mukh Bhasrika} training for 12 weeks. Cardiovascular autonomic reactivity tests were performed before and after the training. The parameters were analyzed by Student's $t$-test. This study showed an increase in parasympathetic activity i.e., reduced basal heart rate, increase in valsalva ratio and deep breathing difference in heart rate; and reduction in sympathetic activity i.e., reduction in fall of systolic blood pressure on posture variation. It was concluded that \textit{Mukh Bhasrika} had beneficial effect on cardiac autonomic reactivity if practiced for a longer duration.

Mazumdar & Suryavanshi\textsuperscript{15} (2010) conducted a study to see the effect of Ujjayi and Bhashrika Pranayama on selected physiological variables of physically challenged students. 60 physically challenged male students were randomly selected as the subjects from Amar Jyoti School and Roshni Rehabilitation Centre, Gwalior.


\textsuperscript{15} Indu Mazumdar, & A. Suryavanshi (2010). Effect of Ujjayi and Bhashrika Pranayama on selected physiological variables of physically challenged students. \textit{British Journal of Sports Medicine}. 41, 69.
All the subjects were divided into two groups i.e. experimental and control group. The experimental group practiced Ujjayi and Bhastrika Pranayama for a period of 6-week. The training was given for 5-day in a week in the morning. Selected physiological variables were vital capacity, positive breath holding time, resting pulse rate and blood pressure. Data was recorded before the training and again after 6-week. The vital capacity was measured with Recorder and Medicare Systems Spirometer (Helios 401) in litres, positive breath holding and resting pulse rate was measured with the help of stopwatch, and blood pressure was measured by Sphygmomanometer and Stethoscope. Paired t-test was employed to analyze the raw data and the mean difference between the pre-test and post-test scores each of the criterion variables of the groups. The level of significance was chosen at 0.05. From the findings, it was observed that t-ratio was insignificant in case of resting pulse rate and diastolic blood pressure; however, in case of vital capacity and positive breath holding time the t-ratio was significant.

Muktamath, & Muktamath (2013) conducted a study to see the effects of Asana, Pranayama and Meditation practice on Resting Pulse Rate. 40 students from Lions High School, Sirsi, Karnataka were randomly selected as subjects. The age of the subjects was ranged between 15 to 17 years. The selected subjects were divided into four groups of 10 subjects each. Group I underwent Asana practice, Group II underwent Pranayama practice, Group III underwent Meditation practice for five days per week for eight weeks of training period and Group IV acted as control group that did not participate in any special training programme apart from their regular activities. The data was collected before and after the training programme of eight weeks. Resting pulse rate was chosen as a criterion variable. The analysis of covariance (ANCOVA) was used to analyze the data. The results of the study revealed that the resting pulse rate significantly improved due to the Asana, Pranayama and meditation practice.

Ray et. al.\(^{17}\) (2011) conducted a study to critically observe the energy expenditure, exercise intensity and respiratory changes during a full yoga practice session. Oxygen consumption (\(V_O^2\)), carbon dioxide output (\(V_C O_2\)), pulmonary ventilation (\(V_E\)), respiratory rate (\(F_r\)) and tidal volume (\(V_T\)), were measured in 16 physical posture (Asana), five yoga breathing maneuvers (BM) and two types of Meditation. Twenty male (age \(27.3 \pm 3.5\) years, height \(166.6 \pm 5.4\) cm and body weight \(58.8 \pm 9.6\) kg) subjects were selected for the study. Their maximal oxygen consumption (\(V_O^2\) max) was recorded. The exercise intensity in Asana was expressed in percentage \(V_O^2\) max. In Asana, exercise intensity varied from 9.9 to 26.5\% of \(V_O^2\) max. Highest energy cost was 3.02 kcal/min\(^{-1}\). In BM highest \(V_E\) was 53.7 \(\pm 15.51\) min\(^{-1}\). VT was 0.97 \(\pm 0.59\), 1.41 \(\pm 1.27\) and 1.28 \(\pm 1\) breath with corresponding \(F_r\) of 14.0 \(\pm 5.3\), 10.0 \(\pm 6.35\), 10.0 \(\pm 5.8\) breaths/min. Average energy expenditure in Asana, BM and Meditation was 2.29, 1.91 and 1.37 kcal/min\(^{-1}\), respectively. Metabolic rate was generally in the range of 1-2 metabolic equivalents (MET) except in three Asanas where it was >2 MET. \(V_O^2\) max was 0.27 \(\pm 0.05\) and 0.24 \(\pm 0.041\) min\(^{-1}\) in Meditation and Shavasana respectively. Although yogic practices were low intensity exercises within lactate threshold, physical performance improvement was possible owing to both better economy of breathing by BM and also by improvement in cardiovascular reserve. Other factors such as psychophysiological and better relaxation might contribute to it.

Pramanik et. al.\(^{18}\) (2009) conducted a study to evaluate the immediate effect of slow pace Bhastrika Pranayama (respiratory rate 6/min) for 5 minutes on heart rate and blood pressure and the effect of the same breathing exercise for the same duration of time following oral intake of hyoscine-N-butylbromide (Buscopan\(^{®}\)), a parasympathetic blocker drug. Heart rate and blood pressure of volunteers (n = 39, age = 25-40 years) were recorded following standard procedure. The Pranayama was conducted in a cool, well-ventilated room (18-20\(^\circ\)C). After 5 minutes of the breathing practice, the blood pressure and heart rate again were recorded in the aforesaid manner. The other group (n = 10) took part in another study where their blood


pressure and heart rate were recorded following half an hour of oral intake of hyoscine-\(N\)-butylbromide 20 mg. Then they practiced the breathing exercise as stated above, and the above mentioned parameters were recorded again to study the effect of parasympathetic blockade on the same Pranayama. It was noted that after slow Bhastrika Pranayama (respiratory rate 6/min) for 5 minutes, both the systolic and diastolic blood pressure decreased significantly with a slight fall in heart rate. No significant alteration in systolic & diastolic blood pressure and heart rate was observed in volunteers who performed the same breathing exercise for the same duration following oral intake of hyoscine-\(N\)-butylbromide. Pranayama increased the frequency and duration of inhibitory neural impulses by activating pulmonary stretch receptors during above tidal volume inhalation as in Hering Buer reflex, which brought about the withdrawal of sympathetic tone in the skeletal muscle blood vessels, leading to widespread vasodilatation, thus causing decrease in peripheral resistance and the diastolic blood pressure. After hyoscine-\(N\)-butylbromide, the parasympathetic blocker, it was observed that blood pressure was not decreased significantly as a result of Pranayama, as it was observed when no drug was administered. Vagal cardiac and pulmonary mechanisms are linked, and improvement in one vagal limb might spill over the other. Baro receptor sensitivity can be enhanced significantly by slow breathing (supported by a small reduction in the heart rate was observed during slow breathing and reduction in both systolic and diastolic blood pressure). Slow pace Bhastrika Pranayama (respiratory rate 6/min) thus showed a strong tendency to improve the autonomic nervous system through enhanced activation of the parasympathetic system.

Shankarappa\(^\text{19}\) (2012) conducted a study to see the effect of short-term Pranayama (6-week) on the pulmonary function parameters. The study group consisted of 50 young adults (26 males and 24 females) newly recruited for yoga training at the Patanjali Yoga Center, Kolar. They were motivated to undergo Pranava, Nadishuddi and Savitri Pranayama training for 1 hour daily for 6 days a week. The data was recorded before and after 6 weeks of the regular Pranayama practice. The selected parameters were FVC, FEV1, PEFR, FEF (25%-75%) and BHT. For all the parameters, a P value of <0.001 was considered as statistically

significant. There was a statistically significant increase in all the above lung parameters in the regular yoga practitioners.

Madanmohan et. al.\textsuperscript{20} (2005) conducted a study to see the effect of slow and fast Pranayama on reaction time and cardio respiratory variables. 30 healthy volunteers of either gender were selected as the subjects for the study. Their age was 15–18 years, weight 40–60 kg and height 155–170 cm. All the subjects were divided into two groups of 15 each. Group I was taught slow breathing Savitri Pranayama while group II was taught fast breathing Bhastrika Pranayama. Practice sessions were conducted five days a week during the morning hours for thirty minutes for a total duration of three weeks. Selected Parameters were maximum expiratory pressure (MEP), maximum inspiratory pressure (MIP), respiratory endurance, breath holding time (BHT), visual reaction time (VRT), auditory reaction time (ART), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean pressure (MP), heart rate (HR), rate-pressure product (RPP) and double product (Do P). The data was recorded from all the subjects before and after the training. The values obtained before and after the training period were compared using paired t-test. Difference of the values between the two groups was compared using student’s t-test. In Savitri Pranayama group there was a significant (P<0.05) increase in MEP, MIP and respiratory endurance. In Bhastrika Pranayama group, there was also a significant (P<0.01) increase in respiratory endurance and MEP while MIP was found insignificant. BHT increased significantly (P<0.05) in Bhastrika Pranayama group and insignificantly in other group. Although there was an insignificant result found in VRT and ART in both the groups. Following three weeks of training, HR, RPP, and DoP decreased in Savitri Pranayama group and increased in Bhastrika Pranayama group and the difference between the two groups was found significant (P<0.05) when compared by students t-test. There was also a significant decrease (P<0.05) in diastolic blood pressure (DBP) in Savitri Pranayama group following three weeks of training.

Raghuraj & Telles (2008) conducted a study to see the immediate effect of specific nostril manipulating Yoga breathing practices on autonomic and respiratory variables. The effect of right, left, and alternate nostril yoga breathing (i.e., RNYB, LNYB, and ANYB, respectively) was compared with breath awareness (BAW) and normal breathing (CTL). Autonomic and respiratory variables were studied on 21 male volunteers with age ranging between 18-45 years. Subjects were assessed in five experimental sessions on five separate days. The sessions were in fixed possible sequences and subjects were assigned to a sequence randomly. Each session was of 40 min. Assessments included heart rate variability, skin conductance, finger plethysmogram amplitude, breath rate, and blood pressure. Following RNYB, there was a significant increase in systolic, diastolic and mean pressure. In contrast, the systolic and diastolic pressure decreased after ANYB and the systolic and mean pressure were lower after LNYB. Hence, unilateral nostril yoga breathing practices appeared to influence the blood pressure in different ways. These effects suggested possible therapeutic applications.

Pramanik (2005) conducted a study to determine the effect of nostril dominance yogic exercise programme on physical and physiological variables. 120 male students of B.Ed. and B.P.E. from N.C.P.E. Noida were selected as subjects for the study. The age of the subjects was 19-25 years. The selected variables were vertical jump, chin ups, shuttle run, peak flow rate, vital capacity, blood pressure (systolic and diastolic), hemoglobin, resting heart rate, maximum heart rate, \( V_{o2} \) max, respiratory rate and physical work capacity. The subjects were randomly assign into four groups i.e. three experimental groups and one control group. Among the experimental group (B, C, & D) were administered three types of practice i.e. B group was assigned Left nostril dominance, C group was assigned Right nostril dominance, and D group was assigned both nostril dominance. Group A served as a control group so it did not participate in any kind of training programme. The respective yogic exercise programme was conducted for a period of 12 weeks. The data was recorded before and after the training programme, t-ratio was employed to find out yogic experimental in each groups. Further in order to study the comparative effect of

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nostril dominance on selected physical and physiological variables, analysis of covariance (ANCOVA) was applied at .05 level of significance. Significant improvement was found in peak flow rate, vital capacity, resting heart rate, respiratory rate, VO\textsubscript{2} max and physical work capacity as a result of the experimental treatments in all the three experimental groups. Significant improvement was also found in vertical jump, shuttle run and maximum heart rate as a result of the experimental treatments namely, Right nostril dominance group and both nostril dominance group. Whereas chin ups, hemoglobin, systolic and diastolic blood pressure were found insignificant in all the three groups.

**Malhotra et. al.**\textsuperscript{23} (2012) conducted a study to see the effect of Anuloma-Viloma Pranayama on reaction time and autonomic activity of heart. Pulse rate and reaction times were recorded before and after twelve cycles of alternate nostril breathing. The pulse rate dropped from 81.5±5.3 to 72.9±8.7. Reaction times dropped from 0.47± 0.15 seconds to 0.38 ± 0.09 seconds. The changes were statistically significant at p<0.001. Alternate nostril breathing is a process of continuous, regularity of inhalation, holding of breath and exhalation. It charges the body with an increased supply of oxygen through the lungs, thus oxygen "burns" or oxidizes the waste impurities chiefly carbon in the venous blood. This process of purification is enhanced by an accompanying large increase in expulsion of waste carbon dioxide from the lungs during exhalation. As a result, very little of the tissue remains in the blood as waste material. There is less need for the breath, as the flow of blood to the lungs for purification slows down. The heart and lungs are given extraordinary rest.

**Bhavanani**\textsuperscript{24} (2014) conducted a study on differential effects of uninostril and alternate nostril pranayamas on cardiovascular parameters and reaction time. The study aimed to determine differential effects of these techniques on reaction time, heart rate and blood pressure. Twenty yoga-trained subjects came to the lab on six different days and RT, HR, and BP were recorded randomly before and after nine rounds of right UNB (surya nadi [SN]), left UNB (chandra nadi [CN]), right initiated


ANB (surya bhedana [SB]), left initiated ANB (chandra bhedana [CB]), nadi shuddhi (NS), and normal breathing (NB). There was an overall reduction in HR and BP-based parameters following CB, CN, and NS with concurrent increase following SB and SN. The differential effects of right nostril initiated (SB and SN) and left nostril initiated (CB, CN, and NS) UNB and ANB techniques were clearly evidenced. Changes following NB were insignificant in all respects. RT showed statistically significant differences between groups that were significantly lowered following both SB and SN. The main effect of UNB and ANB techniques was determined by the nostril used for inspiration rather than that used for expiration. It is concluded that right and left yogic UNB and ANB techniques had differential physiological effects that were in tune with the traditional swara yoga concept that air flow through right nostril (SN and Pingala swara) is activatory in nature, whereas the flow through left nostril (CN and Ida swara) is relaxatory.

Malhotra (2009) conducted a study on Suryanadi Anuloma-Viloma Pranayama modifies autonomic activity of heart. The study was designed to see the scientific basis of the effect of pranayama on the heart. Pulse rate was recorded before and after twelve cycles of left nostril breathing. Thirty two readings were taken. The pulse rate dropped from 71.19±6.3 to 65.88±5.6. The change was significant at p<0.001.

M. Jayachitra (2011) analyzed the effect of pranayama and bandha practices on selected physiological variable among adolescent girls. To achieve this purpose, three groups of 20 such girls each were randomly selected as subjects and named as ‘bandha group’ (BG) ‘pranayama group’ (PG) and ‘combined group’ (CG). BG and PG underwent selected bandha and Pranayama practice respectively whereas CG underwent the combination of both pranayama and bandha practice for six weeks. The selected subjects were tested before (pre test) and after (post tests) the practice period on the selected variables for the research work and were statistically treated by applying ANCOVA and Scheffe’s Post Hoc test. The result of this study proved that


selected bandha and pranayama practice could make significant changes on the physiological functions i.e. FVC, PEFR, BHT and RRR among adolescent girls.

**Bhavanani, & Madanmohan** (2012) conducted a study on Suryanadi Pranayama (Right Unilateral Nostril Breathing) which may be safe for Hypertensives. The study was designed to determine the immediate effects of 27 rounds of SNP on cardiovascular parameters in patients of essential hypertension (HT). This has clinical significance in determining whether such a potentially sympathomimetic practice is safe in such a population. 20 hypertensive patients on standard medical management were taught to perform SNP by qualified yoga instructors. Heart rate (HR) and blood pressure (BP) were recorded after 5 minutes of rest in sitting posture and after 27 rounds of SNP. All data passed normality testing and hence was analyzed using Students t test for paired data. Statistical analysis revealed no significant changes in any of the parameters following SNP. Gender-based subanalysis revealed no significant differences between male and female subjects. The absence of any significant increase in HR or BP following SNP did not go against earlier theories that it might be dangerous for hypertensive patients due to its sympathomimetic nature. SNP might not increase HR and BP in subjects because they already had reached a certain threshold of reactivity. The goal of yoga is to restore homeostasis. Hence, if sympathetic reactivity of a subject is already higher than normal, yogic techniques will not further increase such a hyper reactivity but rather bring it back to normal. The small 1-2% decrease in most parameters in the study gives a hint of this possibility. In conclusion, the study evidenced that exclusive right nostril breathing, as performed in SNP, might be safe in patients of HT. It was also concluded that the cardiovascular effects of SNP in hypertensives were different than those reported by previous studies carried out on normal subjects. Further studies may throw light on possible mechanisms involved and also whether there is any difference produced by long term training in SN.

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Shirley, Nagarathna, & H.R. (2008) conducted a study to assess the physiological effects of yoga breathing practice that involves breathing exclusively through the right nostril. This practice is called surya anuloma viloma pranayama (SAV). 12 volunteers (average age 27.2 ± 3.3 years, four males & eight females) were assessed before and after test sessions conducted on two consecutive days. On the first day the test session involved practicing SAV pranayama for 45 minutes (SAV session). During the test period of the other day, subjects were asked to breath normally for 45 minutes (NB session). For half the patients (randomly chosen) the SAV session was on the first day and the NB session on the next day. For the remaining six patients, the order of the two sessions was reversed. After the SAV session (but not after the NB) there was a significant (P < .05, paired t test) increase in oxygen consumption (17%) and in systolic blood pressure (mean increase 9.4 mmHg) and a significant decrease in digit pulse volume (45.7%). The latter two changes were interpreted to be the result of increased cutaneous vasoconstriction. After both SAV and NB sessions, there was a significant decrease in skin resistance (two factors ANOVA, Tukey test). These findings showed that SAV has a sympathetic stimulating effect. This technique and other variations of unilateral forced nostril breathing deserve further study regarding therapeutic merits in a wide range of disorders.

Shirley et. al. (1994) conducted a study on breathing through a particular nostril can alter metabolism and autonomic activities. The study aimed at checking whether such changes actually do occur, and whether breathing is consciously regulated. 48 male subjects, with ages ranging from 25 to 48 years were randomly assigned into different groups. Each group was asked to practice one out of three pranayamas (viz. right nostril breathing, left nostril breathing or alternate nostril breathing). These practices were carried out as 27 respiratory cycles, repeated 4 times a day for one month. Parameters were assessed at the beginning and end of the month. The 'right nostril pranayama' group showed a significant increase of 37% in baseline oxygen consumption. The 'alternate nostril' pranayama group showed an 18% increase, and the left nostril pranayama group also showed an increase of 24%.

Jain, Srivastava, & Singhal\(^\text{30}\) (2005) conducted a study on the effects of right and left nostril breathing on cardio-respiratory and autonomic parameters. In the study the responses of right nostril breathing (RNB) and left nostril breathing (LNB) on cardio-respiratory and autonomic functions were investigated in healthy students of both sexes. The RNB and LNB groups comprised of 10 males and 10 females in each in the age range of 17–22 years. Initially, in both groups control values of respiratory rate (RR), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), peak expiratory flow rate (PEFR) and galvanic skin resistance (GSR) were recorded. The same parameters were recorded after 15 min (acute exposure) and 8 weeks of training in RNB and LNB. In males RR (P<0.0001), SBP (P<0.05) and DBF (P<0.05) fell significantly after 15 min of RNB. After 8 weeks training in RNB, HR (P<0.01) decreased, SBP (P<0.001) declined more profoundly and RR (P<0.0001) and DBP (P<0.05) decrement was maintained. After 15 min of LNB, RR (P<0.01), HR (P<0.01), SBP (P<0.001) and DBP (P<0.01) declined significantly, on 8 weeks training, RR (P<0.0001) and HR (P<0.01) decreased further, the decrement in SBP (P<0.001) and DBP (P<0.01) was the same. In females, RR alone fell significantly (P<0.05) after 15 min RNB. After 8 weeks RR decrement was more profound (P<0.0001) and DBP also declined significantly (P<0.01). Similarly, 15 min LNB resulted in significant reduction in RR (P<0.001) and HR (P<0.05) only. Following 8 weeks of training in LNB, in addition to RR (P<0.0001) and HR (P<0.05) decrement, SBP (P<0.01) and DBP (P<0.05) also fell significantly. Both in males and females, GSR did not change significantly (P>0.05) either after RNB or LNB (15 min/8 weeks). PEFR rose significantly (P<0.05) only in females after 8 weeks of LNB. The results suggested that there were no sharp distinctions between effects of RNB and LNB either acute exposure (15 min) or after training (8 weeks). However, there was a general parasympathetic dominance evoked by both these breathing patterns.

Malhotra et al. (2010) conducted a study to see the effect of Chandra nadisuddhi pranayama on yoga practitioners and a naïve subject. Chandra nadisuddhi pranayama is simply a left nostril breathing exercise. The heart rate was taken immediately before and after each session, which consisted of twelve cycles of Chandra nadisuddhi pranayama. The mean heart rate of the yoga practitioners dropped from 73.94 ± 2.71 to 65.89 ± 2.02 and that in the naïve subject it dropped from 79.83 ± 3.26 to 76.14 ± 2.31 after Chandra nadisuddhi Pranayama. The drop was significant at p<0.001 in both the cases. But the drop was high in case of the yoga practitioners. So, it was concluded that the effect of pranayama was the same in all, but to a higher degree in experienced yoga practitioners than in a naïve person.

Subbalakshmi et al. (2005) conducted a study on immediate effect of Nadi-shodhana Pranayama on some selected parameters of cardiovascular, pulmonary, and higher functions of brain. The study was designed to determine whether Nadi-shodhana Pranayama practice for 20 minutes had any immediate effect on heart rate, systolic and diastolic blood pressure, peak expiratory flow rate, and simple problem solving ability. 10 normal healthy students of first year physiotherapy course were selected as the subjects for the study, ageing between 17-20 years. Among them, five were females and five were males. They did not have any previous training in Pranayama. All the selected physiological parameters were measured before and after performing Nadi-shodhana Pranayama. Two sets of controls were done in the matched subjects by allowing them to relax in a couch (A) or close their eyes with quiet breathing for 20 minutes. Following Nadi-shodhana Pranayama of 20 minutes, a significant decline in basal heart rate (P<0.0001) and systolic blood pressure (P<0.001) was observed. Peak expiratory flow rate significantly improved (P<0.01) and the time taken for simple problem solving was significantly less following pranayama practice (P<0.0001). In contrast, both control subjects did not show any significant change in respiratory and cardiovascular parameters with 20 minutes. The study suggested that the Nadi-shodhana Pranayama rapidly altered cardiopulmonary responses and improved simple problem solving. Further studies on a larger sample size need to illustrate the underlying mechanisms involved in this alteration.


Malhotra et al. (2010) conducted a study to see the changes in pulse rate after three pranayamas i.e. Suryanadisuddhi pranayama (SNP), Chandranadisuddhi Pranayama (CNP) and Anuloma-Viloma Pranayama (AVP). Pulse rate was recorded before and after twelve cycles of right nostril breathing. 32 readings were taken. The pulse rate dropped from 71.19±6.3 to 65.88±5.6. The change was significant at p<0.001. Pulse rate was recorded before and after 12 cycles of left nostril breathing. 60 readings were taken. The pulse rate dropped from 73.7±5.3 to 66.7±3.2. The change was significant at p<0.001. Pulse rate was recorded after five minutes of rest and after 12 cycles of Nadisuddhi pranayama. 66 readings of the subjects were taken. The pulse rate dropped from 81.5±5.3 to 72.9±8.7. The change was significant at p<0.001 (using paired test). These three pranayamas charged the body with an increased supply of oxygen through the lungs.

Pratap (1972) reported that although the ideal pattern indicated by the ancient Rishis could not be verified significantly yet there was some kind of pattern of nostril breathing which differed from day to day and person to person.

Vijayan et al. (2000) conducted pulmonary function tests (spirometry and maximal expiratory flow rates) on south Indian healthy children between 7-19 years of age to predict pulmonary function. The correlations of forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were, in general highest with height followed by weight and age. Peak expiratory flow rate (PEFR) also significantly correlated with physical characteristics.

Howard et. al.\textsuperscript{36} (2001) carried out a study to find Spirometric pulmonary function in healthy preschool children ageing 3 to 6 years. 82.6\% of participants were able to perform technically acceptable and reproducible maneuvers during a testing session limited to 15 min. PEFR, FVC, FEV1, and FEF 25-75 all increased with increasing height; the final outcome of the study was that spirometry could be obtained in the majority of preschool children. Many preschool-aged children were able to perform technically acceptable and repeatable spirometry under normal conditions in a busy clinical setting. Spirometry may be a useful screen for abnormal lung function in this age group.

D. Milner et. al.\textsuperscript{37} (1970) conducted study on children between 2 years 4 months and 4 years 9 months to prove that good reproducible results for peak expiratory flow rates could be obtained from children over the age of 3 years using the low-range Wright Peak Flow Meter.

\begin{itemize}
  \item \textsuperscript{37}D. Milner, A. D. & D. Ingram (1970). Peak Expiratory Flow Rates in Children Under 5 Years of Age. \textit{Archives of Disease in Childhood}, 45 (244), 780-782
\end{itemize}