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*Original Article*

# IMMEDIATE EFFECT OF 'NADI -SHODHANA PRANAYAMA' ON SOME SELECTED PARAMETERS OF CARDIOVASCULAR, PULMONARY, AND HIGHER FUNCTIONS OF BRAIN

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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 is designed to determine whether Nadi-shodana pranayama practice for 20 minutes has any immediate effect on heart rate, systolic and diastolic blood pressure, peak expiratory flow rate, and simple problem solving ability. Ten normal healthy subjects of first year physiotherapy course volunteered for this study. They were aged between 17-20 years. Among them, five were females and five were males. They did not have any previous training in Pranayama. They were highly motivated to participate in this study program. Study procedures were done separately for each subject at the same time of the day between 4-5 pm. 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 was 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 present study suggests that the 'Nadi-shodhana Pranayama' rapidly alters cardiopulmonary responses and improves simple problem solving. Further studies on a larger sample size need to illustrate the underlying mechanisms involved in this alteration.

***Key words***: Nadi-shodhana pranayama, heart rate, blood pressure, peak expiratory flow rate, problem solving ability

With increased awareness and interest in health and natural remedies, yogic techniques including pranayama are gaining importance and becoming increasingly acceptable to the scientific community. Pranayama literally means control of prana. *Prana,* in Indian philosophy, refers to all forms of energy in the universe. Life force is one part of this

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energy. Life force in an individual is symbolized by breathing. That is why pranayama is generally considered to mean regulated breathing. A yogi, throug pranayama, can, at some stages, control other functions of his body and finally control manifestations of prana even outside his body (Bijlani, 2004).

As a technique, pranayama can assume rather complex forms of breathing, but the essence of the practice is slow and deep breathing. Such breathing is economical because it reduces dead space ventilation. It also refreshes air throughout the lungs, in contrast with shallow breathing that refreshes air only at the base of the lungs (Bijlani, 2004). Pranayama breathing has been shown to alter autonomic activity. A study by Udupa et al. (1975) indicates that pranayama training produces a decrease in basal sympathetic tone. Raghuraj et al. (1998) have reported that Nadi-shodhana pranayama increases parasympathetic activity. Slow and deep breathing itself has a calming effect on the mind and helps an individual to de-stress (Sandeep et al., 2002). This calming effect may also exert profound physiological effects on pulmonary, cardiovascular, and mental functions of the brain. This study investigated the immediate effect of a type of slow pranayama called as 'Nadi-shodhana' on resting heart rate, blood pressure, peak expiratory flow rate, and simple problem solving ability in young healthy subjects.

## Materials and Methods

This study was carried out in Human Physiology Laboratory, Department of Physiology, Sikkim Manipal Institute of Medical Sciences, Gangtok. Fifty healthy volunteers were recruited and separated into study and control groups. They were aged between 17-20 years. All were doing Bachelor degree in Physiotherapy. They were highly motivated to participate in this study and allowed to quit any time. In the study group, thirty subjects were screened and 10 subjects (5 females and 5 males) were found to be highly motivated to take part in the study as well could perform the exercise as instructed. Their average body mass index was 21.59 ± 2.83. There were two control groups (Group A and Group B, n = 10 each) that matched for age, sex, and body mass index to the study group. Studies parameters included heart rate, systolic and diastolic blood pressure, peak expiratory flow rate, simple problem solving ability to explain the cardiopulmonary function and mental efficiency.

**Study protocol**

The trainer involved in this study addressed the class of 30 students on the purpose of this study, the procedure to be followed, and willingness of the subjects to participate in this investigation. After the address, the trainer demonstrated the mode of Nadi-shodhana pranayama to the subjects. Among these 30 students, only 10 subjects met the study criterion. Another 20 subjects matched for sex, age, and body mass index of subjects in the study group were selected from a batch of 50 students. These were randomly allotted to control group A and B. Each subject was studied separately and twice at the same time (4.00-5.00 pm). In the study group, a recording was done before and immediately (within 5 minutes) after performing 'Nadi-shodhana Pranayama'. In control group A, the recording was done before starting to relax in a couch and immediately after (within 5 minutes) 20 minutes resting period. In control group B, the recording was done before performing quiet breathing in any comfortable sitting posture and immediately after (within 5 minutes) 20 minutes quiet breathing with closed eyes.

**'Nadishodhana Pranayama' training** (Bhargava et al., 1988)

After an initial recording, all subjects were put through Nadi-shodhana pranayama for 20 minutes. They were asked to assume 'Sukhasana' (the comfortable posture) and regulate the alteration of breathing as follows:

1. Open the right hand and bend index and middle fingers against the palm. The thumb was used for closing the right nostril while the fourth and fifth fingers were used for the left nostril.

2. Place the right thumb against the ala at the end of the nostril to close it and similarly press the fourth and fifth fingertips against the left nostril.

3. Start the exercise in the 'Sukhasana posture', with relaxed attitude and concentration as below.

3.1 Exhale slowly and deeply without closing the nostrils but being ready to do so.
3.2 Inhale slowly and quietly through the left nostril while closing the right.
3.3 At the end of the inhalation, close both nostrils and hold the breath for a while (not more than 1-2 seconds).
3.4 Keep the left nostril closed and exhale through the right as quietly as possible.
3.5 After exhaling completely, inhale slowly and quietly through the right nostril.
3.6 Close both nostril and wait for a while, then open the left nostril and exhale slowly and silently.
3.7 Inhale through the same nostril and continue.

**Parameter measurements**

Heart rate was measured by counting radial pulse for a minute. Three readings were taken and their average was recorded. Both systolic and diastolic blood pressures were measured with the auscultatory method by using sphygmomanometer and stethoscope. Three readings were taken and their average was recorded. Peak expiratory flow rate was measured using a pocket peak expiratory flow meter (a mini version of Wright peak flow meter). The subject was asked to take a deep breath and then to blow hard into the mouthpiece of the flow meter with a sharp blast. The movement of the needle on the dial indicated the peak expiratory flow rate in liters per minute. Four recordings were taken at one-minute intervals and the average of the three highest readings was noted down.

Mental efficiency (simple problem solving ability) was estimated as follows: A simple arithmetical problems of three-digit numbers involving addition, subtraction, multiplication, and division were given. Two sets of questions comprising of 10 problems. Each was prepared and students were asked to pick up one set by 'lottery system'. The time taken to solve all the questions was noted down.

## Statistical analyses

All the values obtained before and after performing 'Nadi-shodhana Pranayama', rest and quiet breathing were expressed as mean ± SD. The Student paired t' test was used to compare parameters within groups. P value of less than 0.05 indicates a significant difference.

## Results

The average age of the study group was 18 years with body mass index of 21.59 ± 2.83. There were 5 males and females in control groups A and B similarly to the study group. The average body mass index of the control group A was 21.43 ± 2.49 and that of the control group B was 21.75 ± 2.77.

The baseline heart rate, blood pressure, peak expiratory flow rate, and times taken to solve the arithmetic problems were comparable between study and control groups. Among the cardiovascular parameters studied, a significant decline in heart rate ($P < 0.0001$) and systolic blood pressure ($P<0.001$) was observed only in the study group (Table 1). Both control groups displayed no significant change in heart rate and systolic blood pressure following 20 minutes rest and quiet breathing (Table 2 and Table 3). Diastolic blood pressure did not change significantly in both study and control groups (Table 1, Table 2, and Table 3). The peak expiratory flow rate improved significantly ($P<0.01$) following pranayama practice (Table 1). No significant change in peak expiratory flow rate was observed in both control groups (Table 2 and Table 3). Although both study and control subjects could solve all the problems correctly (the data not shown), the time taken to solve the problems decreased significantly only after practice of Nadi-shodhana pranayama (P<0.0001, Table 1). Twenty minutes rest and quiet breathing had no significant effect on the time taken to solve the problems (Table 2 and Table 3).

**Table 1.** Immediate effect of Nadi-shodana pranayama on cardiovascular, pulmonary, and mental efficiency parameters. Data were mean ± SD; n = 10

| Parameters | Before pranayama | After pranayama | Mean difference | 't' value | P value |
|---|---|---|---|---|---|
| Basal heart rate (beats/minute) | 85.9 ± 4.6 | 74.6 ± 4.1 | 11.3 ± 4.0 | 8.92 | <0.0001 |
| Systolic blood pressure (mmHg) | 120.9 ± 5.8 | 116.6 ± 4.6 | 4.3 ± 2.2 | 6.14 | <0.001 |
| Diastolic blood pressure (mmHg) | 79.0 ± 2.3 | 78.2 ± 2.1 | 0.8 ± 1.4 | 1.81 | NS |
| Peak expiratory flow rate (l/minute) | 419.0 ± 67.4 | 483.3 ± 75.2 | 64.3 ± 50.4 | 4.03 | <0.01 |
| Problem solving ability (second) | 90.8 ± 24.9 | 69.5 ± 21.8 | 21.3 ± 10.0 | 6.72 | <0.0001 |

## Discussion

Since yoga aims at perfection of the body and mind, it is natural to ask whether the progress towards perfection is reflected in objective reproducible changes in physiological variables. In general, yogic practices have been proposed to reduce heart rate and blood pressure (Bhargava et al., 1988). However, no study indicates a decline in blood pressure (Udupa et al., 1975). Yogic asanas and pranayama have been shown to reduce the resting respiratory rate and increase vital capacity, timed vital capacity, maximum voluntary ventilation, breath holding time and maximal inspiratory and expiratory pressures (Nayar et al., 1975; Joshi et al., 1992). Anand and his colleagues (1961) observed a preponderance of alpha waves in the EEG of yogis, indicating a more relaxed state of mind. Shirley Telles and her colleagues at Swami Vivekananda Yoga Research Foundation reported that, during meditation, there was a significant reduction in heart rate but an increase in cutaneous peripheral vascular resistance, indicating a physiologically relaxed state but increased mental alertness (Telles and, Desiraju, 1993). Some recent studies have shown that unilateral forced nostril breathing affects cerebral hemispherical dominance (Naveen et al., 1997). Left-sided unilateral forced nostril breathing leads to right-hemisphere dominance and improves

**Table 2.** Cardiovascular, pulmonary, and mental efficiency parameters in controlgroup A. Data were mean ± SD; n = 10

| Parameters | Baseline | After 20 minutes rest | Mean difference | 't' value | P value |
|---|---|---|---|---|---|
| Basal heart rate (beat/minute) | 84.8 ± 4.4 | 83.9 ± 4.3 | 0.9 ± 1.8 | 1.58 | NS |
| Systolic blood pressure (mmHg) | 121.7 ± 4.3 | 120.6 ± 3.4 | 1.1 ± 1.9 | 1.82 | NS |
| Diastolic blood pressure (mmHg) | 79.2 ± 2.7 | 79.1 ± 2.6 | 0.4 ± 2.1 | 0.61 | NS |
| Peak expiratory flow rate (l/minute) | 421.6 ± 41.2 | 422.2 ± 51.6 | 0.6 ± 31.1 | 0.05 | NS |
| Problem solving Ability (second) | 900 ± 21.9 | 89.0 ± 21.9 | 1.0 ± 1.6 | 1. 94 | NS |

**Table 3.** Cardiovascular, pulmonary, and mental efficiency parameters in control group B. Data were mean ± SD; n = 10

| Parameters | Baseline | After quiet breathing | Mean difference | 't' value | P value |
|---|---|---|---|---|---|
| Basal heart rate (beat/minute) | 84.1± 4.5 | 83.2 ± 4.3 | 0.9 ± 1.5 | 1.87 | NS |
| Systolic blood pressure (mmHg) | 121.3 ± 4.2 | 120.7 ± 4.0 | 0.6±1.0 | 1.97 | NS |
| Diastolic blood pressure (mmHg) | 79.5 ± 2.8 | 79.1 ± 2.5 | 0.4 ± 0.8 | 1.50 | NS |
| Peak expiratory flow rate (l/minute) | 417.8 ± 65.5 | 420.9 ± 63.0 | 3.1 ± 5.5 | 1.72 | NS |
| Problem solving Ability (second) | 91.4 ± 23.6 | 90.6 ± 23.3 | 0.8 ± 1.5 | 1.64 | NS |

spatial skills while right-sided unilateral forced nostril breathing induces left-hemisphere dominance and increases verbal skills (Jella and Shannahoff-Khalsa, 1993). With this background, this study investigated the immediate effect of Nadi-shodana pranayama on some selected physiological parameters indicative of cardiovascular, pulmonary, and higher brain functions.

Although a significant decline in basal heart rate observed in the present study is in accordance with the findings of Udupa et al. (2003), it has some differences. In his study, in addition to nadi-shodhana pranayama, other types of pranayama were also included and the training period was of three months. A significant decline in systolic blood pressure in the present study is in accordance with the findings of Bhargava et al. (1988) who evaluated the nadi-shodana pranayama effect after 4 weeks of regular practice. Pranayama is an art of control of breathing. A practitioner of pranayama not only tries to breathe, but at the same time, also tries to keep his/her attention on the act of breathing, leading to concentration. These acts of concentration remove his attention from worldly worries and de-stress him/her. This stress free state of mind evokes relaxed responses (Bijlani, 2004). In this relaxed state, parasympathetic nerve activity overrides sympathetic nerve activity (Udupa et al., 2003). Therefore, the significant decline in basal heart rate and systolic blood pressure in the pranayama practice could be largely due to better parasympathetic control over the heart.

Diastolic blood pressure mainly varies with the degree of peripheral resistance (Guyton, 1996) and heart rate. The non-significant change in diastolic blood pressure observed in the present study suggests that 'Nadi-shodhana Pranayama' might have no any immediate effect on peripheral vascular resistance or it has some roles, but is obscured by a slow heart rate.

A significant improvement in peak expiratory flow rate was observed in the present study (Table 1). It is an effort independent flow and is mainly dependent on lung volume. The 'Nadi-shodhana Pranayama' involves using of lung spaces, not used up in normal shallow breathing. Therefore, the increased peak expiratory flow rate might be a consequence of small airway opening in lungs.

The results of the present study not only demonstrated the beneficial effect of Nadi-shodhana pranayama on cardiopulmonary function but also demonstrated its positive impact on higher functions of the brain. To best of our knowledge, there are no studies in the past studying the effect of pranayama practice on simple arithmetic problem solving ability. Problem solving is considered as a mental stress causing sympathetic arousal (Bernardi et al., 2000). Yogic practices are reported to cause a shift in autonomic balance towards parasympathetic dominance (Bijlani, 2004). Yogic practices have been shown to reduce baseline average glucocorticoid levels. However, the glucocorticoid response to an acute challenge is enhanced. These findings indicate a lower level of stress and enhanced capacity to cope up with a challenge (Kamei et al., 2000). In the present study, the students following pranayama took significantly less time in solving problems compared to time taken for solving the problems prior to the training ($P<0.0001$). In the present study, while performing breathing practice, subjects were also emphasized to concentrate on the act of breathing. This act of breathing removes his attention from worldly worries and de-stress. This stress free individual adapts better to the daily emotional, physical, and mental stresses. Therefore, the significantly less time taken to solve the mathematical problems could be due to better adaptability for mental stress induced by breathing act for 20 minutes.

The positive results found in the present study might apply to work places to improve work efficiency and to educational institutes to improve learning ability. A few minutes practice daily may help in setting the mind better on works and studies. The daily practice could also be parts of physical fitness and life style modification programs in maintaining better physical and mental health. Although the present study suggests some applications, further studies with larger number of subjects from different lifestyles need to establish the beneficial effects of pranayama practice.

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