

## Original Research Article

# Pranayama improves cardio-respiratory efficiency and physical endurance in young healthy volunteers

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### ABSTRACT

**Background:** Pranayama involves manipulation of the breath, which is a dynamic bridge between body and mind. The aim of the study was to compare cardio respiratory parameters before and after pranayama practice and to correlate the changes in physical endurance with the changes in cardio-respiratory parameters.

**Methods:** A quasi experimental study was conducted among 120 healthy students in the age group 18-25 years. These students were given pranayama practice for 30 minutes a day for 3 days in a week for 12 weeks. The subjects were assessed for various cardio-respiratory parameters like respiratory rate (RR), forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), FEV1/FVC, peak expiratory flow rate (PEFR), breath holding time (BHT), Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), hand grip and rate of oxygen uptake per minute (VO<sub>2</sub>max) before and after pranayama practice. Statistical analysis included descriptive statistics, paired t test and Pearson correlation.

**Results:** There was a significant decrease in RR, HR, SBP and DBP after pranayama practice. BHT, FVC, FEV1, PEFR, hand grip and vo<sub>2</sub> max were significantly increased after pranayama practice. Physical endurance is positively correlated with hand grip and heart rate.

**Conclusions:** The results emphasize the health benefits of pranayama. Regular pranayama improves the cardiovascular efficiency and physical endurance. In spite of yogic training being not very vigorous, cardio-respiratory efficiency was found to increase. Pranayama practice can be advocated to improve cardio-respiratory efficiency for patients as well as healthy individuals.

**Keywords:** Blood pressure, Physical endurance, Pranayama, Respiratory function test, Yoga

### INTRODUCTION

Yoga is becoming very popular in all parts of the world. For the restless mind it gives solace, for the sick it is a boon. With its multifold advantages, it is becoming a part of education. The term yoga has its verbal root as (YUJ) in Sanskrit. Yuj means joining or union: union of mind, body and spirit. As a holistic approach the science of yoga reveals the art of living and not just the exercise of the mechanical performance of rituals.<sup>1</sup> In other words, yoga is a way of life, an exploration of self-knowledge

and self-development. Yoga is a science which is practiced since thousands of years with increase of awareness in health. Yoga produces physiological changes and has sound scientific basis.<sup>2</sup> The aim of yoga is the development of integrated balance between body and mind.<sup>3</sup> Patanjali, a foremost exponent of yoga, described pranayama as the gradual unforced cessation of breathing.

Pranayama is derived from two sanskrit words- Prana (life) or Ayama (control). Prana means an inner life force,

which provides energy to different organs and control vital life processes. Ayama means voluntary effort to control and direct the prana. Pranayama involves manipulation of the breath, which is a dynamic bridge between body and mind. Pranayama consists of three phases: Puraka (inhalation) kumbhaka (retention) and rechaka (exhalation) that can be either fast or slow.<sup>4,5</sup> Slow pranayama like nadishudhisavitri and pranav pranayama have been shown to decrease heart rate, systolic blood pressure and diastolic blood pressure. Fast pranayamas like kapalbhati and bhastrika when practiced alone, increased the sympathetic activity. Breathing exercise (pranayama) for a minimum of 3 weeks are reported to influence cardiorespiratory and autonomic functions.<sup>6-9</sup> Some studies have found that there is no effect for fast pranayama after 12 weeks of practice. Few studies have shown the benefits of pranayama on physical endurance. There were not many studies in literature which investigate the beneficial effects of pranayama on cardio-respiratory parameters and physical endurance. In this study, authors are exploring the benefits of pranayama on VO<sub>2</sub> max, physical endurance and cardio-respiratory parameters.

## METHODS

A Quasi experimental study was done among healthy non smoker student volunteers in the age group 18 - 25 years of Amala Institute of Medical Sciences, Thrissur during the period January 2017 to August 2018. Subjects with past or present history suggestive of cardiovascular, respiratory illness, any other systemic illness, history of major surgery in the recent past., family history of asthma, allergic diseases, history of cigarette smoking, tobacco chewing, alcohol intake, previous experience of yoga training, history of active sports training or those who are on any medication were excluded from the study. Institutional Research Committee and Ethical committee clearance was obtained prior to starting the study (No: AIMSIEC/02/2017 dated 07.01.2017).

### Sample size

In a study done by Pradnya et al, it was observed that  $\mu_1$  - 76.06,  $\mu_2$  - 77.42 (diastolic BP values before and after pranayama).<sup>10</sup>

Calculation:  $n \text{ pairs} = [Z_{1-\alpha/2} + Z_{1-\beta}]^2 + Z_{21-\alpha/2} / \Delta^2$

$\Delta = (\mu_2 - \mu_1) / \sigma$ ,  $\sigma = \sigma_1 + \sigma_2 / 2$ ,  $\alpha 0.05 = 1.96$  (rejection true null hypothesis),  $\beta = 0.84$  (assumption false null hypothesis), Power = 80%, minimum sample size  $n = 116$ .

A written consent was taken from all participants in the study. Before including the subjects for the study, all the subjects were assessed through history taking. Before starting the work, the students were given detailed information about the study and every attempt was taken to solve their queries. This was an attempt to make good

rapport with subject and relieve their anxiety. Only those subjects who fulfilled the inclusion criteria were included in the study. All the parameters were collected during evening hours, between 4 pm to 5.30 pm at room temperature, to avoid any possible diurnal variation effect. The details of the procedure of step test were explained to the subjects and actually demonstrated beforehand to allay apprehension. All the data were recorded in the proforma for each subject. The participants were subjected to the measurement of anthropometric variables like height, weight, body mass index (BMI), Systolic and diastolic blood pressure (SBP and DBP), respiratory rate, other respiratory parameters like Forced vital capacity (FVC), FEV<sub>1</sub>, peak expiratory flow rate (PEFR), breath holding time, Timed vital capacity (TVC) were measured using lung spirometer. The predicted VO<sub>2</sub> max was calculated by Harvard step method and Hand grip endurance was measured using hand grip dynamometer.

After collecting the data from all 120 subjects, pranayama practice was given by a trained yoga practitioner for 12 weeks. Pranayama practice included kapalbhati, bhastrika, nadishodana, pranav and savitri pranayama for 30 minutes in a day, thrice a week. Sessions were conducted in the hematology lab of physiology department at 4 pm. Attendance was marked each day before starting the session. After 12 weeks of pranayama practice all the post session parameters were collected.

### Statistical analysis

Variables obtained before and after pranayama were expressed as mean  $\pm$  standard deviation. Paired t test was used for comparing the data obtained before and after pranayama. Pearson test was used to correlate the changes in physical endurance and cardiorespiratory parameters. A  $p < 0.05$  was considered as significant.

## RESULTS

The study included 120 subjects, of which 83 were females and 37 were males. The demographic data is depicted in table 1. The mean weight of the subjects before and after pranayama sessions were  $56.84 \pm 13.63$  and  $56.69 \pm 13.46$  respectively. But the reduction in weight was not statistically significant ( $p > 0.05$ ). The mean body mass index also decreased after 12 weeks of pranayama practice ( $22.80 \pm 5.16$  vs  $22.74 \pm 5.12$ ). But it was statistically not significant. The cardiovascular parameters showed significant reduction after the sessions (Table 2). The mean heart rate showed a reduction from  $77.85 \pm 10.96$  to  $75.20 \pm 10.71$  number/min after the completing the practice. Both systolic and diastolic blood pressure showed a significant reduction when compared to the measurement prior to the practice. The mean systolic BP and mean diastolic BP were  $107.97 \pm 12.94$  and  $69.41 \pm 8.83$  respectively before the session, while after the session they were  $105.05 \pm 12.57$

and 66.46±8.59 respectively. Both these differences were highly statistically significant (p=0.0001).

**Table 1: Anthropometric parameters before and after pranayama sessions.**

Anthropometric parameters	Before pranayama sessions	After pranayama sessions
Height (cm)	157.90±9.09	157.90±9.09
Weight (kg)	56.84±13.63	56.69±13.46
BMI (kg/m <sup>2</sup> )	22.80± 5.16	22.74±5.12

Values expressed as mean±SD, n=120. p>0.05

**Table 2: Comparison of cardio-respiratory parameters and handgrip before and after pranayama sessions.**

Parameters	Before pranayama sessions	After pranayama sessions	p value
Heart rate	77.85±10.96	75.20±10.71	0.0001
Respiratory rate	15.62±1.72	13.87±1.60	0.0001
SBP	107.97±12.94	105.05±12.57	0.0001
DBP	69.41±8.83	66.46±8.59	0.0001
BHT	45.03±14.49	58.41±16.90	0.0001
FVC(L)	3.51±0.58	3.64±0.58	0.0001
TVC(L)	2.82±0.45	2.93±0.47	0.0001
FEV1/FVC	80.58±2.04	80.57±2.44	0.957
PEFR (L/min)	360.31±47.87	388.60±47.91	0.0001
VO2max (mL/kg/min)	29.71±3.55	32.05±4.05	0.0001
Hand grip	101.93±56.91	127.71±56.94	0.0001

Values expressed as mean±SD, n=120.

The respiratory parameters also showed significant improvement after the pranayama sessions (Table 2). The mean respiratory rate decreased from 15.62±1.72, before practice to 13.87±1.60 after the practice. Both FVC and TVC showed improvement after 12 weeks practice of pranayama. FVC showed improvement from 3.51±0.58 to 3.64±0.58 whereas TVC was improved from 2.82±0.45 to 2.93±0.47 (p=0.0001). The PEFR improved significantly from 360.31±47.87 before the practice to 388±47.91 after the practice (p=0.0001). However, FEV1/FVC did not show significant difference (p=0.957). Breath holding time also showed significant increase from 45.03±14.49 before the practice to 58.41±16.90 after the practice (p=0.0001). Among the parameters measured, VO2 max showed significant improvement from 29.71±3.55 before the session to 32.05±4.05 after pranayama practice (p=0.0001). The physical endurance as measured by hand grip showed vast improvement from 101.93±56.91 to 127.71±56.94 (p=0.0001).

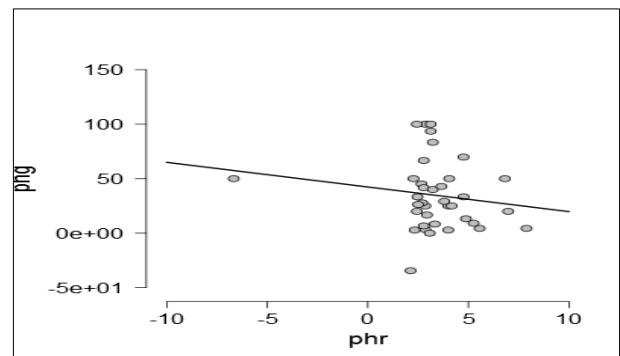
Correlation of cardiorespiratory parameters with hand grip is given in table 3. On applying Pearson's correlation, it was found that among the cardiorespiratory

parameters only heart rate and breath holding time were showed significant positive correlation with the hand grip (p<0.001). Pearson's correlation coefficient for heart rate and breath holding time with hand grip were 0.443 and 0.381 respectively. The significant positive correlation between heart rate and breath holding time with the hand grip were given in figure 1 and 2 respectively.

**Table 3: Correlation of cardio-respiratory parameters with physical endurance.**

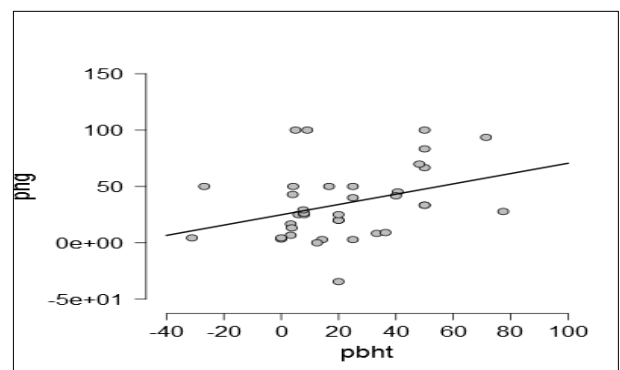
Parameter	Correlation coefficient (r)	p value
Heart rate	0.443	<0.001
Respiratory rate	0.103	0.350
Systolic Blood pressure	-0.025	0.818
Diastolic Blood pressure	-0.122	0.269
Breath holding time	0.381	<0.001
FVC(L)	0.137	0.213
TVC(L)	-0.052	0.638
FEV1	-0.128	0.247
PEFR	0.070	0.526
VO2max	0.155	0.159

p value <0.05 is considered significant



X axis-change in percentage of HR (phr); Y axis-Change in percentage of Hand grip (phg)

**Figure 1: Correlation between handgrip endurance and heart rate.**



X axis-Change in percentage of Breath holding time (pbht); Y axis- Change in percentage of Hand grip (phg)

**Figure 2: Correlation between hand grip endurance and breath holding time.**

## DISCUSSION

In this study, a statistically significant fall in the cardiovascular parameters such as heart rate and blood pressure (both SBP and DBP) were observed. This fall can be attributed to profound increase in vagal tone and thereby parasympathetic predominance caused due to performing the pranayama. This increased vagal tone decreases heart rate, thereby decreases the work load on heart leading to decrease in cardiac output and hence SBP. Yogic practices alter the hypothalamic discharge leading to decrease in sympathetic tone and peripheral resistance and hence decrease the DBP. Similar observation was found in a study conducted by Bharshankar et al where there was a statistically significant fall in heart rate and SBP after a one month training of pranayama was demonstrated.<sup>11</sup> However, they did not observe any significant fall in DBP.

The isometric handgrip strength which is an autonomic parameter was also statistically improved. This improvement is a reflection of increased parasympathetic tone which brings in a sense of calmness in the subject. In our study, authors found that the respiratory parameters like respiratory Rate, FEV1, FVC, and PEFr improved after the pranayama training and this improvement was statistically significant. The pranayama technique per se causes an almost complete inflation and deflation of lung. During this process the respiratory muscles get strengthened, the surfactant and prostaglandins will be released by the alveolar cells (by mechanical stimulus during the inflation/deflation).<sup>12-14</sup> The surfactant improves the lung compliance while the prostaglandins improve the smooth muscle tone. These physiological changes brought about during the pranayama training might be responsible for the improvement of the above mentioned parameters.

The breath holding time also improved significantly following the pranayama training. This again can be attributed to the physiological factors mentioned above that has improved the PFT, and other factors like, improvement of compliance of the thorax and improvement of muscle endurance caused due to breathing exercise.<sup>15,16</sup> These exercises cause a marked increase in PO<sub>2</sub> and fall in PCO<sub>2</sub> because of the near total inflation of the lung that occurs during the slow and deep breathing pranayama performed by the participants. This increase in PO<sub>2</sub> and PCO<sub>2</sub> will prolong the breath holding time.<sup>17</sup> In normal breathing after a particular degree of stretching or even before this, stretch receptors in alveoli are stimulated and send information to the respiratory centers so that exhalation sets in. But in pranayama, there is continuation of the phase of inhalation with strong voluntary control so that lungs are expanded considerably and the walls of the alveoli are stretched to the maximum extent. Thus the chest continues to get expanded under cortical control. The stretch receptors are thus trained to withstand more and more stretching. This helps in holding the breath for a longer time. As the duration of

breath holding during pranayama is gradually increased by practice, the respiratory center is acclimatized to withstand higher and higher carbon dioxide concentrations in the alveoli and the blood. In some yoga breathing, one uses extremely rapid, shallow breathing and in other type, makes each successive breath nearly equal to his vital capacity. These prolonged efforts at controlling respiratory muscles, thus consciously and persistently overriding the usual excitatory stimuli to the respiratory centers, thus acquires some degree of control over the respiration. Also the receptors get acclimatized to the increased concentrations of carbon dioxide gradually by regular practice of pranayama.<sup>18</sup> In addition, increased development of respiratory musculature and endurance due to regular practice of pranayama delays the onset of fatigue, thus allowing the breath holding for longer time. Practice of meditation along with pranayama produces a hypo metabolic state of the body characterized by decreased carbon dioxide production and decreased oxygen consumption, thus allowing breath holding for a longer time.<sup>19</sup> This finding is consistent with the study performed by Ankad et al in which they demonstrated that BHT improved significantly after 15 days of regular pranayama practice.<sup>20</sup>

The Aerobic capacity (vo<sub>2</sub> max) describes the functional status of the cardio respiratory system. It is defined as maximum volume of O<sub>2</sub> that can be consumed by one's muscle during exercise.<sup>14</sup> The VO<sub>2</sub> max value improved after the pranayama training. The pranayama training as mentioned before affects the cardiovascular as well as the respiratory system by improving the ventilation to the lungs and the perfusion to the heart. The slow deep breathing allows more ventilation and hence increases PO<sub>2</sub> levels. This will contribute to the improvement in the aerobic exercise capacity which is reflected as an improvement in VO<sub>2</sub> max. Our finding is consistent with the study by Bauri et al. where they studied the effect of short term yoga training on VO<sub>2</sub> max and aerobic work capacity.<sup>21</sup>

Even though many studies were carried out previously to investigate the effects of pranayama on cardiorespiratory parameters, physical endurance and VO<sub>2</sub> max, none of them dealt with the effects on all the parameters together.<sup>22-25</sup> So, by this study it was proved beyond doubt that pranayama has got beneficial effects on cardiorespiratory parameters, physical endurance and vo<sub>2</sub> max. Furthermore, authors found a correlation between cardiorespiratory parameters like heart rate and breath holding time with physical endurance. Both males and females included in the study were not in equal number. So unable to compare the gender difference remains the major limitations of the study.

## CONCLUSION

There was a significant decrease in cardiovascular parameters like heart rate, systolic blood pressure and diastolic blood pressure after 12 weeks of pranayama

practice. The respiratory parameters such as respiratory rate, FVC, TVC, FEV1, PEFR, breath holding time showed a significant increase after pranayama. Physical endurance was also increased after the pranayama and it showed a positive correlation with heart rate and breath holding time. Vo2 max was significantly improved after pranayama. So, it can be concluded that practicing pranayama for a period of 12 weeks can improve the cardio-respiratory parameters, physical endurance and VO2max.

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