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Effect of Deep Breathing Exercise on Heart Rate Variability of Different Age Groups

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ABSTRACT

Breathing affects our respiratory, cardiovascular, neurological, gastrointestinal, muscular, and psychological well-being. Breathing also has a general effect on our sleep, memory, and ability to concentrate and plays an important role in improving our energy level. To study the effect of deep breathing exercise on heart rate variability of different age group. Pranayama, most known as deep breathing exercises, is a compound word with Pran and Ayama. The increase in HRV may be since the reduction in breathing frequency caused by the breathing training allows the respiration to modulate the sympathetic cardiac outflow along with the vagal outflow which result in increased HRV. Compare the heart rate variability and autonomic function test between two groups before practicing deep breathing exercise. Compare the heart rate variability and autonomic function test between two groups after practicing deep breathing exercise. To find out the effect of regular practice of slow deep breathing exercise in two groups.

Key words: Breathing, Pranayama, HRV, Sympathetic cardiac

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INTRODUCTION

"Your breathing determines whether you are at your best or whether you are at a disadvantage'' by CAROLA H SPREADS. Breathing a little bit slower can have long-term health benefits [1]. Deep breathing activates a relaxation response, it can also potentially decrease the inflammation, improve the cardiovascular and the immune system and hence may improve longevity [2]. Breathing affects our respiratory, cardiovascular, neurological, gastrointestinal, muscular, and psychological well-being. Breathing also has a general effect on our sleep, memory, and ability to concentrate and plays an important role in improving our energy level [3]. We can control the body by regulating breathing; So only the great Napoleon Bonaparte preferred a man with wide nostrils, presumably because his breathing facilities are better.

Deep breathing is defined as "mean voluntary and full inflation of the lungs fully carried, slowly and regularly performed, and generally accompanied by movements of the arms, chest, and abdominal walls. This deep breathing is marked by expansion of the abdomen rather than the chest when breathing [4]. Deep breathing also goes by the names of diaphragmatic breathing, abdominal breathing, belly breathing, and paced respiration. Of all the autonomic functions of the body namely cardiovascular, digestive, hormonal, glandular and immune system only the act of breathing can be easily controlled voluntarily. Richard et al has mentioned in their work that by voluntarily changing the rate, depth, and pattern of breathing, the messages sent from the body's respiratory system to the brain can be changed. In this way, breathing techniques provide a portal to the autonomic communication network through which we can, by changing our breathing patterns, send specific messages to the brain using the language of the body, a language the brain understands and to which it responds [5].

The use of diaphragmatic breathing is commonly practiced, especially in those patients with cardiopulmonary disease, to improve a variety of factors such as pulmonary function [6] cardiorespiratory fitness [6] posture [7] respiratory muscle length [8] and respiratory muscle strength [9]. Deep breathing is one of the simple powerful relaxation techniques used from ancient time & can be practiced almost anywhere [10-12]. Deep Breathing Exercise (Yoga) as a therapy is simple and inexpensive and can be easily adopted in most patients without any complications [13].

In general, the human system is not designed to always breathe deeply and in all situations. Though deep breathing is considered as an advantageous method, it can be practiced only as a regulated exercise. Pranayama, most known as deep breathing exercises, is a compound word with Pran and Ayama. Pran means breathing or respiration and Ayama means extension or expansion. Thus, Pranayama means extension of breath or life span. During pranayama the mind must concentrate on breathing process. Pranayama or cooling breath [14]. Sama Vritti or Equal Breathing [5] Ujjayi Pranayama or ocean breath [6] Skull Shining Breath or Kapalabhati Pranayama [7] Abdominal Breathing Technique [8] Bhramari Pranayama or breathing with humming sound [9] Udgeet Pranayama. Cardiovascular diseases are the leading cause of death globally. It also increases the morbidity. By early detection and treatment, we can prevent the progress of cardio vascular disorders.

Heart rate (HR) exhibits an oscillatory pattern in synchrony with the respiratory cycle, which is denominated respiratory sinus arrhythmia (RSA) [15-17]. During inspiration, the HR increase is largely due to withdrawal of the parasympathetic activity on the sinus node. During expiration, the parasympathetic resumes activity and HR decreases [15]. Heart rate variability (HRV) has come to be widely used as a noninvasive tool to assess autonomic function in a variety of physiologic as well as disease states. Heart rate variability (HRV), the beat-to-beat variation in either heart rate or the duration of the R-R interval, has become a popular clinical and investigational tool [18-20].

A reduced HRV is associated with a poorer prognosis for a wide range of clinical conditions while, conversely, robust periodic changes in R–R interval are often a hallmark of health [18,21-23]. Although HRV and RSA are not quite the same, these terms are often used interchangeably, and both are widely believed to reflect changes in cardiac autonomic regulation [24]. Heart rate variability is the analysis of the cardiac autonomic regulation through quantification of sinus rhythm variability.

MATERIALS AND METHODS

Randomized interventional study group includes undergraduate students, post graduate students, staff members of Sree Balaji Medical College.

Inclusion criteria

- ✓ Healthy volunteers.
- ✓ Both males & females.
- ✓ In the age group of 18 to 35 years.

Exclusion criteria

- ✓ Smokers, alcoholics, obese persons.
- ✓ Known case of Diabetes Mellitus, Hypertension, Cardiovascular disorders, Respiratory problems, Psychological disorders, Neurological diseases & Cerebro vascular illness.
- ✓ Subjects practicing regular Exercise, Yoga, Meditation.
- ✓ Persons working on night shifts.
- ✓ Taking medications affecting Autonomic Function Tests.

Study group

This study was performed in Department of Physiology, Sree Balaji Medical College& Hospital, Chromepet. 50 Healthy volunteers were included. They were divided into 2 groups based on their age.

Group I

25 normal healthy volunteers in the age group of 18 to25 years includes both Males & Females.

Group II

25 normal healthy volunteers in the age group of 26 to 35 years includes both Males & Females.

Study protocol

Ethical committee clearance was obtained from Institutional ethical committee. Written informed consent was taken from the subjects after explaining them about the whole procedure and the tests involved. Bhastrika Pranayama or slow deep breathing exercise was taught to all the 50 volunteers. Dates were given to all the subjects in such a way that 2 subjects can be tested in one day. The subjects were instructed not to practise deep breathing exercise until further instructions were given to them.

Prerequisites

The subjects were asked to avoid exercise, heavy physical activity (running, playing outdoor games, weightlifting) the previous day & on the day of the test. They were asked to come the previous day of the test to the department & they were given clear instructions. They were asked to have a light meal and come to lab 2 hours after light meal (28,72,73). They were asked to report to the Research Laboratory in the department of Physiology at 8.30am.

METHODOLOGY

Questionnaire was given to all the subjects. Family history (parental H/O DM, HT, CAD), Personal H/O (Smoker, Alcoholics), H/O Drug intake were recorded through questionaire. Anthropometric measurements namely Height and Weight was measured followed by resting HR and BP. The BMI was calculated as the weight in kilograms divided by the square of the height in meters (weight (kg) /height (m2)). The subjects were asked to empty the urinary bladder. They were asked to lie down on the couch and adviced to rest and relax; Watch, bracelets, metallic objects& mobile phones were removed from their body for to prevent interference with the datas. Heart Rate Variability was measured by using POWERLAB PRO which was followed by the autonomic function tests. Battery of autonomic function test (isometric handgrip test, cold pressor test, ortho static standing test, HRV during deep breathing test) were done for the same group of subjects.

RESULTS

Figure 1 indicates male and female distribution of both groups. Table 1 indicates that baseline parameters among two groups. Equal distribution of Height, Weight, BMI, Heart rate, Systolic blood pressure, Diastolic blood pressure seen between two age groups.

Statistical analysis

All the values are expressed in mean ± standard deviation. Student 't' test was applied to compare the parameters in Group I and Group II. p value<0.05 was considered significant at 95% level and p value<0.00 was considered significant

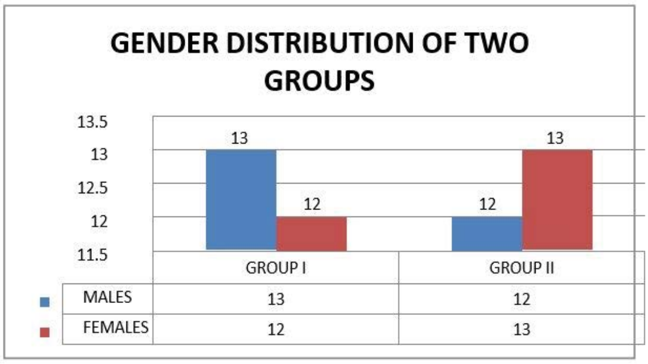

Figure 1: Male and female distribution of both groups.

Table 1: Baseline parameters among two groups.

Parameters	Group I	Group II	P Value
Age(years)	19 ± 0.78	30.40 ± 2.92	8.37E-24
Height (cm)	162 ± 10.20	162.84 ± 8.16	0.529
Weight (kg)	62 ± 13.78	66.76 ± 10.99	0.823
BMI	24.18 ± 3.76	25.17 ± 3.82	0.648
HR (beats/min)	87.04 ± 12.40	84.44 ± 13.52	0.62
SBP (mmHg)	110.04 ± 13.10	109.92 ± 13.83	0.739
DBP (mmHg)	72.48 ± 10.14	74.04 ± 8.51	0.657

at 99% level. To compare the parameters among Group I & Group II was analysed using student T test. All the results were computed using SPSS software, 15.0 version.

Figure 2 shows the comparison of SBP, DBP during Isometric handgrip test in group I & group II. Figure 3 shows comparison of SBP, DBP during cold pressor test in group I and group II before practicing deep breathing exercise. After practicing of slow deep breathing exercise of six months (Tables 2 to Table 9) and (Figures 4 and Figure 5).

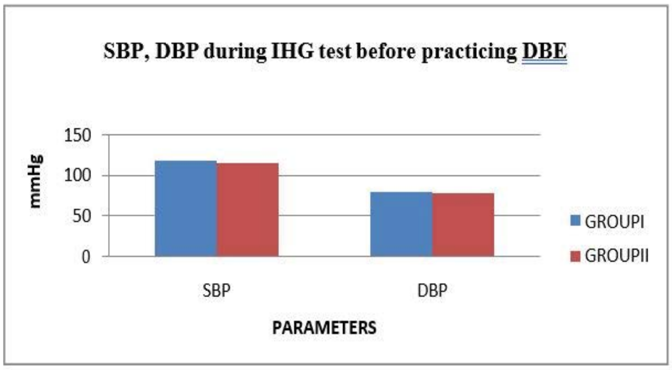

Figure 2: Comparison of SBP, DBP during isometric handgrip test in group I & group II.

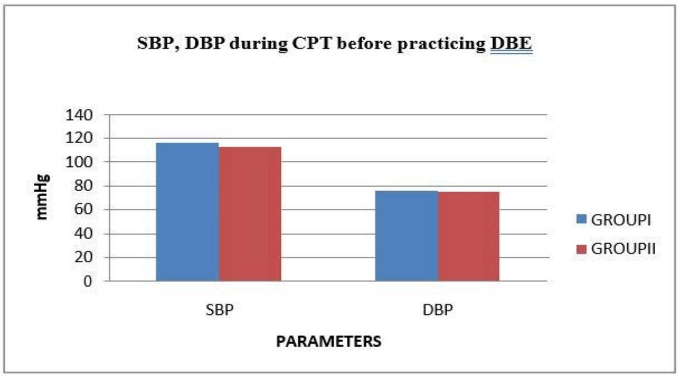

Figure 3: Comparison of SBP, DBP during cold pressor test in group I and group II before practicing deep breathing exercise.

Table 2: Indicates baseline heart rate, SBP, DBP after practicing deep breathing exercise.

Parameters	Group I	Group II	P Value
SBP (mmHg)	110.04 ± 8.25	112.68 ± 10.79	0.002
DBP (mmHg)	73.92 ± 5.58	75.44 ± 6.95	0.419
HR (beats/min)	80.81 ± 7.65	80.56 ± 8.74	0.25

Table 3: Time domain variation between 2 groups after practicing deep breathing exercise.

Parameters	GROUP I	GROUP II	P Value
ARR (ms)	669.71 ± 73.99	712.46 ± 71.50	0.04598
MRR (ms)	667.24 ± 75.99	709.98 ± 76.52	0.05856
SDRR (ms)	47.35 ± 15.96	43.84 ± 20.26	0.5624
SDARR(s)	6.01 ± 3.98	3.09 ± 9.28	0.628
AvR (beats/min)	91.28 ± 11.11	85.35 ± 17.78	0.034
SDR (beats/min)	6.341 ± 2.25	5.00 ± 1.93	0.037
pRR50(%)	11.36 ± 10.16	12.39 ± 13.15	0.69

Table 4: Frequency domain variation between 2 groups after practicing deep breathing exercise.

Parameters	Group I	Group II	P Value
LF (nu)	47.88 ± 14.69	47.75 ± 16.63	0.968
HF (nu)	49.67 ± 13.42	49.31 ± 14.69	0.858
LF/HF Ratio (%)	1.12 ± 0.739	1.28 ± 1.12	0.566

Table 5: Indicates SBP, DBP and heart rate during, 2mins, 5mins, Isometric handgrip test after practising deep breathing exercise.

	SBP (mmHg)		DBP (mmHg)		HR (beats/min)	
	Group I	Group II	Group I	Group II	Group I	Group II
During	118.63 ± 8.5	116.4 ± 10.87	77.85 ± 6.63	76.36 ± 6.51	86.88 ± 8.18	83.72 ± 10.9
2Mins	111.15 ± 9.06	109.72 ± 8.53	72.77 ± 7.25	72.84 ± 7.46	80.03 ± 8.31	77.44 ± 9.08
5Mins	104.04 ± 9.05	101.12 ± 7.85	64.81 ± 7.31	67.76 ± 7.22	72.33 ± 7.257	70.28 ± 7.64

Table 6: Indicates SBP, DBP and heart rate during, 2mins, 5mins, cold presser test after practicing deep breathing exercise.

	SBP (mmHg)		DBP (mmHg)		HR (beats/min)	
	Group I	Group II	Group I	Group II	Group I	Group II
During	116.07 ± 9.5	117.44 ± 11.47	75.77 ± 7.14	75.04 ± 7.67	85.77 ± 8.64	81.24 ± 7.36
2Mins	106.59 ± 8.35	108.08 ± 11.13	68.59 ± 6.64	69.4 ± 4.49	76.81 ± 9.18	73.28 ± 6.16
5Mins	98.07 ± 7.35	101.2 ± 7.81	62.14 ± 4.57	62.8 ± 6.61	67.92 ± 6.72	67.16 ± 5.71

Table 7: Indicates HR, SBP, DBP on lying posture, immediately after standing after practicing deep breathing exercise.

	SBP (mmHg)		DBP (mmHg)		HR (beats/min)	
	Group I	Group II	Group I	Group II	Group I	Group II
Lying Posture	115.63±7.47	117.76±8.64	76.55±5.05	80.28±4.80	84.85±10.24	79.16±8.38
Immediately after standing	107.96±8.87	111.96±9.17	70.185±6.32	75.2±6.02	79.44±10.41	74.24±8.83

Table 8: Indicates E/I after practicing deep breathing exercise.

Parameter	E/I Ratio
Group I	1.06 ± 0.162
Group II	0.9268 ± 0.1743
P Value	0.000005

Table 9: Comparison of LF, HF, LF/HF Ratio between 2 groups.

	GROUP I			GROUP II			P Value
Parameters	Before DBE	After DBE	Difference	Before DBE	After DBE	Difference	
LF (nu)	67.78	47.89	19.89	59.71	47.76	11.95	0.003
HF (nu)	31.23	49.67	18.44	39.14	49.32	10.18	0.002
LF/ HF (%)	2.5	1.13	1.37	1.94	1.28	0.66	0.01

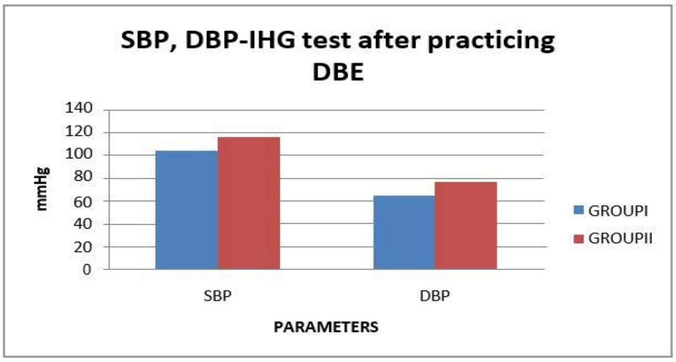

Figure 4: Comparison of HR, SBP, DBP during Isometric handgrip in group I & group II.

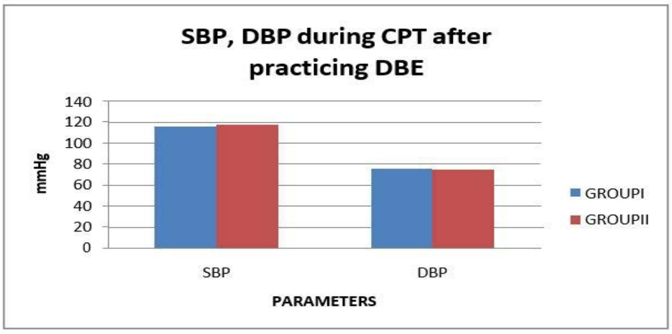

Figure 5: Comparison of SBP, DBP during cold pressor test in group I and group II after practicing deep breathing exercise.

DISCUSSION

This study was done to find out the effect of deep breathing exercise on heart rate variability of different age groups. Our study included 50 normal healthy volunteers. We divided them into 2 groups. Group I included 13 males and 12 females in the age of 18 to 25 years; Group II included 12 males and 13 females in the age of 26 to 35 years; Baseline measurement of Heart Rate Variability & Battery of Autonomic Function Tests namely Iso metric handgrip test, Cold pressor test, HRV during Deep Breathing, Orthostatic Standing Test were performed in both the groups before practicing deep breathing exercise. Then Deep Breathing Exercise was taught to all the subjects. We adviced them to practice deep breathing exercise 30 minutes daily for 6 months. We followed them through phone calls. At the end of 6 months, we repeated all the tests and compared the effects of deep breathing exercise in each group separately. We also compared the effect of age on HRV and AFT before and after practicing deep breathing exercise.

In our study, though not statistically significant we observed a decrease in SBP, DBP and basal HR, in both the groups after practicing deep breathing exercise for 6 months indicating sympathetic inhibition. This is in par with the study done by Roberts et al. where they have observed a reduction in systolic and diastolic BP after practicing slow deep breathing exercise at the rate of 6 BPM for 4 weeks [25]. In a study done by Cuttle et al. it was found that deep breathing exercise when practiced for 10 minutes daily for 3 months reduces stress and promotes calmness thereby decreasing sympathetic activity and increasing para sympathetic activity. Also, deep breathing at rate of 6 breaths per minute increases baro reflex sensitivity and reduces sympathetic activity and chemo reflex activation which produces reduction in SBP and DBP [26].

It is possible that Deep breathing bring about withdrawal of sympathetic tone in skeletal muscle blood vessels exercise when practiced, this may lead to widespread vasodilatation, thus causing decrease in peripheral resistance in turn decreases the DBP. The decrease in SBP may be due to increased vagal tone and decreased sympathetic activity as suggested by Westbrook et al. [27]. In our study, we measured both time domain and frequency domain parameters. However, for short term HRV, Frequency domain parameters reflect autonomic functions. Time domain parameters are better commented on long term or 24 hours ECG acquisition [18]. In both groups, after practicing slow deep breathing exercise for 6 months, there was an increase in HRV indicating parasympathetic dominance.

The HF value was significantly increased in both the groups after 6 months of practicing deep breathing exercise indicating an increase in the parasympathetic activity. LF/HF Ratio value was significantly decreased in both a group after 6 months of practicing deep breathing exercise. This is in par with the study done by Siegelbaum et al. where they found that simple deep slow breathing exercise, without any associated yogic practices, when practised for short term of one month duration, increased the HF and decreased the LF values [24].

In a study done by Westbrook et al. [27] again it was reported that slow deep breathing exercise when practiced for a month reduces blood pressure and increases heart rate variability in young healthy adults. The increase in HRV may be since the reduction in breathing frequency caused by the breathing training allows the respiration to modulate the sympathetic cardiac outflow along with the vagal outflow which result in increased HRV. In a study done by Pal et al, it was found that practicing slow deep breathing exercise for 3 months increases the parasympathetic dominance whereas practicing fast deep breathing exercise for same duration does not have this effect on HRV. This supports the fact that slow deep breathing exercise modulates the sympathetic and vagal outflow which results in increase in HRV [28].

It was also postulated by Matsumoto et al that voluntary slow deep breathing functionally resets the autonomic nervous system by means of two ways. (i) Pranayama increases frequency and duration of inhibitory neural impulses by activating stretch receptors of the lungs during above tidal volume inhalation (as seen in the Hering Breuer's reflex). Further Pranayama improves the generation of hyperpolarization current by stretch of connective tissue (fibroblasts) localized around the lungs. It is found that an inhibitory impulse, which is produced by slowly adapting receptors (SARs) in the lungs during inflation [28], play a role in controlling autonomic functions such as breathing pattern, airway smooth muscle tone, systemic vascular resistance, and heart rate [19]. Stretches of connective tissue fibroblasts are capable to affect the membrane potential of nervous tissue [21]. Both hyperpolarization and inhibitory impulses which is produced by stretch of neural and non-neural tissue of the lungs are the likely agents of autonomic shift during pranayamic breathing. Inhibitory current synchronizes rhythmic cellular activity between the cardiopulmonary center [21] and the central nervous systems. Inhibitory current regulates excitability of nervous tissues [24]. It is known to elicit synchronization of neural elements which typically is indicative of a state of relaxation [25]. Synchronization which occurs within the hypothala mus and the brainstem is responsible for inducing the parasympathetic response during breathing exercises [26].

In our study we have asked the subject to practice deep breathing for 6 months which is a long duration. In our study we found that improvement in parasympathetic activity as indicated by an increase in HF value and increase in HRV was more in group I than group II. This change may be due to increase in the elasticity of the lungs. Because deep breathing exercise reduces the respiratory rate and increases the inspiratory flow rate. It may result in increase in gas exchange. Hence there is reduction oxygen consumption and workload done by heart [27].

Ageing is associated with an increased dependency on sympathetic control of cardiac responses and reduced vagal responsiveness. The blunted vagal modulation of the heart may be related to altered neural vagal discharge to sino atrial node or change in the ability of the cardiac pacemaker itself. Several cardiac electro physiological studies have demonstrated a progressive decline in sino atrial conduction and sinus node recovery with age. studies have revealed increase in empty schwan cell bands or reduced number of fibers in the vagus nerve among old subjects [29,30]. Altered autonomic modulation with ageing also explained by dysfunction of baro receptor mechanism. Increase in circulating levels of norepinephrine and thereby sympathetic over activity might account for reduced vagal efferent drive-in advancing age. In our study, it was observed that, there was increase in SBP, DBP, HR during Iso metric handgrip test and cold pressor test even after practicing deep slow breathing exercise for 6 months in both groups. This same amount of increase in SBP, DBP and heart rate was observed in both the groups before and after practicing slow deep breathing exercise [31,32]. This is in par with the study done by Bhimani et al. [33] Even though there was a reduction in resting BP after practicing deep breathing exercise, there was increase in SBP and DBP in response to stress like isometric hand grip and cold pressor test. This rise was almost the same in both groups. Physical stress increases SBP and DBP by flight are fight response. The increase in BP is necessary for proper function of the human body during stress.

Both Iso metric hand grip and cold pressor test causes peripheral vaso constriction mediated by adrenergic receptors of sympathetic nervous system which results in increase in SBP and DBP. In a study done by Bhimani et al. [33] it was found that there was increase in DBP in response to cold pressor and isometric hand grip test after practicing pranayama for 2 months. In our study immediately after standing there was increase in SBP and DBP in both groups. This increase was more in Group II than Group I. This contrasts with the study done by Newberg et al. Where they found significant reduction in BP from supine to standing posture [28]. Immediately after standing because of pooling of blood in the lower extremities, there is decrease in venous return and decrease in cardiac output, there by decrease in the systolic blood pressure and diastolic blood pressure does not change or there is a small increase in the diastolic blood pressure [34]. The increase in the SBP and DBP observed in our study may be due to the associated anxiety on getting up and standing of the procedure.

HRV during deep breathing is an overly sensitive and specific marker for autonomic function test. It can be well explained by using E/I ratio. Anant Narayan et al did his study on assessment of effects of pranayama/alternate nostril breathing on the parasympathetic nervous system in young adults. They found out there was increase in E/I Ratio after practicing alternate nostril breathing for the short duration of 5 minutes for 6 weeks [26].

In our study, E/I ratio was increased after practicing deep breathing exercise for 6 months in both age groups. This improvement was more in Group I than Group II. The increase in E/I Ratio also indicates the parasympathetic dominance.

CONCLUSION

Hence We can conclude that, there was increase in HRV, that is predominance of parasympathetic tone at the end of 6 months, after practicing of slow deep breathing exercise for 30 minutes daily for the duration of 6 months. There was also an increase in parasympathetic activity indicated by an increase in E/I Ratio during deep breathing. So effect of slow deep breathing exercise was more in the age group of 18 to 25 years than in the age group of 26 to 35 years. Practicing of slow deep breathing exercise is more beneficial to younger age group.

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ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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