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Impact of Meditation and Pranayama on Autonomic Nervous System Balance

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Abstract: Introduction: This study investigates the effects of yoga, specifically meditation and pranayama, on the autonomic nervous system (ANS) functions. **Methods**: Thirty healthy volunteers were taken for the study. Heart Rate variability and Ewingbattery of autonomic tests comprises analysis of heart rate variations during deep breathing test (DBT), lying to standing test (LST), standardized Valsalvamanoeuvre (VM), Cold Pressor test (CPT) and sustained handgrip (SHG) were conducted before and after the intervention. **Results:** Results showed significant changes in systolic blood pressure (SBP), diastolic blood pressure (DBP)and delta values of SBP and DBP in Ewing battery tests. A highly significant decrease in NN50 and pNN50 and a significant increase in Valsalva ratio was also observed. The findings suggest that yoga, particularly meditation and pranayama, can positively influence autonomic functions. **Conclusion:** The findings suggest that meditation have positive effects on Autonomic Nervous System Balance.

Keywords: Meditation, Autonomic function.

INTRODUCTION

Yoga is essentially a spiritual discipline, the practice of which leads to perfect harmony between body and mind. It is called the science of self-realization, based on moral percepts, ascetic, meditation techniques, and a particular type of physical training, which includes the control of posture and respiration.[1]Though this tradition is thought to have originated in India in 5000 BC, it has been incorporated into modern medicine during the past few decades because of increasing incidence of faulty lifestyle and stress related diseases of modern civilization like obesity, hypertension, coronary artery diseases, and diabetes mellitus.

Some physiological benefits of yoga are stable Autonomic nervous system equilibrium, increased Galvanic Skin Response, Cardiovascular efficiency, Respiratory efficiency, Endurance, Energy level, improved Immunity and integrated functioning ofbody parts.[2]

Hence, Yoga is considered to be the best lifestyle modification, which aims to attain the unity of mind, body and spirit through asanas (exercise), pranayama (breathing), and meditation. Pranayama, the art of prolongation and control of breath, brings breath to conscious awareness and moulds the breathing patterns.[2,3]Meditation is recognized as a state in which deep relaxation and increased internalized attention co-exist. A working definition of meditation has been developed by Cardoso *etal.*[4]However, meditation provides deeprest to the system by allowing the mind to calm down to its basal states and serves as a relaxation technique and can be used for treating stress and stress-related illnesses.[5]

In Yogic practices, the parasympathetic nervous system dominates, and increase activity of subcortical region of the brain is observed. [6]

The present study was planned to collect more data to bridge the gaps in our knowledge and to study the effect of meditation and pranayama on human subjects. This study was carried out to know the physiological effects of3 weeks of combined practice of pranayama and meditation in influencing HRV andEwing Battery of tests for Autonomic functions in young healthy individuals of 18–22 years of age.

MATERIAL AND METHODS

The present study was conducted in the physiology department at Subharti Medical College, Meerut. Thirty healthy volunteers were selected for the study. All the subjects were explained about the procedures to be undertaken and written informed consent was obtained. Volunteers aged 18-22 years were screened, detailed medical history was taken to exclude any disorder that can interfere with autonomic functions. Subject with contraindication for exercise training, smoking, obesity, hypertension, COPD were also excluded.

Autonomic functions were tested by a battery of five tests developed by Ewing and Clark in 1981 in Edinburgh, and later validated by the American Diabetes Association [7, 8].

Autonomic function tests, including cardiovascular responses to various stimuli, were conducted pre and post-intervention. Detailed procedures for data collection, including BP measurement, heart rate variability analysis, and isometric exercise tests, were outlined. The Institutional Ethics Committee approved the study protocol.

All subjects underwent the following tests before and after three weeks of Pranayama and Meditation to assess Autonomic functions.

1. Autonomic Function Test

Autonomic function tests were performed at the Research Lab, Department of Physiology Subharti Medical College, Meerut

Prior instructions were given to the subjects before recording that they should not:

1. Consume any medicine 24 hrs before recording.
2. Consume tea, coffee, other caffeinated beverages, and heavy meals at least 2 hours before the recording.

The subjects were instructed about the test and recording procedure, before starting the test andwere made to relax for few minutes.

Basal BP and Heart Rate (HR)

Accusure TD-3127 system, Taiwan, was used for BP recording. BP was recorded after five minutes of resting in the sitting position. The machine's display screen noted Systolic BP, Diastolic BP, and Basal heart rate.

Heart Rate Variability (HRV)

Lead II ECG recording was done in a lying posture at a speed of 25 mm/sec and voltage of 10 mm/MV for 330 seconds to obtain HRV using the data acquisition system RMS- Polyrite AD version 2.2. The data was analyzed in both the frequency and time domains.

In frequency domain analysis, the entire spectrum of frequencies is divided into three major frequency bands. Each bandwidth's area under the curve was calculated and expressed in arbitrary units.

Hand grip test (HGT)

The isometric exercise test used a light, small handgrip. The baseline BP was recorded in sitting posture; the subjects were instructed to press the dynamometer with their dominant hand with the maximum possible force. The 30% of the maximum voluntary contraction (MVC) was calculated, and then the subjects were instructed to press the dynamometer continuously at 30% of their MVC for 4 minutes by their dominant hand. BP was recorded at the 1^{st}, 2^{nd}, and 4^{th} minute of isometric contraction, and the 5^{th}-minute value was measured as recovery after the termination of isometric contraction. The systolic and diastolic BP differences from resting values were calculated at the 1^{st}, 2^{nd}, and 4^{th} minute.

Cold pressor test (CPT)

Before the test, baseline BP was recorded. The subjects were asked to immerse their hand till the wrist in 4.5^0C cold water for 2 min. BP was recorded from the other arm at the 1^{st} and 2^{nd} min. of immersion, and the 5th-minute value was recorded as recovery.

Diastolic and systolic pressure changes were calculated at 1^{st} and 2^{nd} minutes from the resting value.

Lying to standing test (LST)

The subjects were asked to stand from the supine position and then stand steady. Blood pressure was measured at 0.5^{th}, 1^{st}, and 2 min. The systolic and diastolic pressure changes were calculated at 0.5^{th}, 1^{st}, and 2^{nd} min of measurement after standing up.

Valsalva maneuver (Valsalva ratio)

Valsalva maneuver was performed on a mercury manometer, which was locally assembled in our laboratory.Using a mouthpiece attached to a mercury manometer, the test volunteers were instructed to increase their intra-thoracic pressure to 40 mmHg and hold it there for 15 seconds while wearing a nose clip.

Continuous EKG recording was done on BPL electrocardiograph – Cardiart 108T-DIGI for 1 min before straining, for 15 seconds during straining, and 45 seconds after the release of strain.

The Valsalva ratio was an index of heart rate changes that occur during a Valsalvamanoeuvre.The Valsalva ratio was taken as the maximum R-R interval in the 15s following expiration divided by the minimum R-R interval.

Deep breathing test (E: I ratio)

The subjects were given continuous signals corresponding to inspiration and expiration to their total capacity without breaking the breath during inhalation and exhalation. The frequency of the cycle was six breaths /min for 1 minute. Phases of respiration were matched manually on ECG. The average of the six widest R-R intervals was measured during the expiratory phase, and similarly, the six shortest R-R intervals were measured during the inspiratory phase. The averaged value of the expiratory R-R interval and inspiratory R-R interval was taken to calculate the E: I ratio.

Bhramari Pranayama and Meditation.

Bhramari Pranayama started by sitting in a Padmasana posture. Then, the eyes were closed with both hands by four fingers and a thumb on the ear. Subjects were instructed to inhale and exhale forcibly with a humming or buzzing sound. Inhalation and exhalation were from both nostrils and not from the mouth; it was started slowly and then accelerated. Bhramari pranayama was done for 10-12 times.

After pranayama, they were instructed to lie supine with arms beside them, facing upwards and eyes closed. Step by step, they were instructed to relax .With the same relaxed and peaceful mind, they meditated on a piece of music played on an audio CD.

RESULTS

Table 1: Effect of Pranayama and Meditation on sympathetic activity.

Variables	**Pre-exercise Mean ± SD**	**Post-exercise Mean ± SD**	**P value**
SBP (mmHg)	118.40 ± 4.789	116.2 ± 3.19	0.0484
DBP (mmHg)	72.6 ± 4.326	70.4 ± 3.748	0.0318
HR (b/min)	72.4 ± 3.978	70.8 ± 3.553	0.0224

SBP- Systolic Blood Pressure, DBP- Diastolic Blood Pressure and HR- Heart Rate.

It shows that the mean SBP, DBP and HR of values 118.40 ± 4.789 mmHg, 72.6 ± 4.326 mmHg, and 72.4 ± 3.978 b/min, respectivelywere reduced to mean SBP, DBP, and HR to 116.20 ± 3.190mmHg, 70.4 ± 3.748mmHg and 70.8 ± 3.553/min, respectively **a**fter three weeks of Pranayama and Meditation

This reduction was statistically significant when the post-intervention value of SBP, DBP, and HR was compared with the pre-intervention value. (p = 0.0484 for SBP) (p=0.0318 for DBP) (p=0.0224 for HR).

Table: 2 Effect of Pranayama and Meditation on Time Domain measures of HRV

Variables	**Pre Mean ± SD**	**Post Mean ± SD**	**P value**
SDNN (ms)	370.854± 175.844	490.215 ± 219.84	>0.05
RMSSD (ms)	471.594 ±204.362	554.196 ± 226.614	>0.05
NN50 (count)	799.5 ± 66.481	751.1 ± 54.394	0.0098
pNN 50 (%)	24.83 ± 5.67	21.18 ± 5.33	0.0039
CV (ms^2)	216029.5±14401.3	256725 ± 91032.2	>0.05

SDNN- Standard deviation of NN interval, RMSSD- square root of the mean squared differences of successive mean NN intervals deviation from arithmetic mean. NN50 - the number of consecutive RR intervals differing more than 50ms, pNN 50 - The percentage of NN 50 intervals, and Variance - Variance is a measure of Statistical dispersion indicating how far from the expected values its values are.

It shows a highly significant decrease in NN50 (p=0.0039) and pNN50 (p=0.0098) from 799.5 ± 66.48count and 24.83% ± 5.67% respectivelyto 751.1 ± 54.39 and 21.18% ± 5.33%.

Insignificant change was observed in any other variable of time domain measure when pre and post-meditative values were compared. Still, SDNN, RMSSD, and CV showed an increasing trend afterPranayama and Meditation.

Table: 3. Effect of Pranayama and Meditation on Frequency Domain measures of HRV.

Variables	**Pre** **Mean ± SD**	**Post** **Mean ± SD**	**P value**
LF (%)	56.85 ± 14.8	54.9 ± 13.11	>0.05
HF (%)	18.29 ± 5.46	19.83 ± 6.03	>0.05
LF:HF ratio(%)	3.57 ± 1.87	3.148 ± 1.427	>0.05
LF nu	87.2 ± 5.95	85.45 ± 7.21	>0.05
HF nu	16.07 ± 4.24	16.42 ± 5.018	>0.05

LF -Low-frequency power percentage, high-frequency power percentage, LF/HF- Low frequency, and High-frequency ratio. In normalized units, LFnu and HF nu- Low and High frequency, respectively.

When pre meditative variable of frequency domain measure were compared with their post meditative variables no significant change was observed in any variable of frequency domain measures of HRV.

Table 4. Effect of Pranayama and Meditation on HGT, CPT and LST

Variables		**Pre** **Mean ± SD** mmHg	**Post** **Mean ± SD** mmHg	**P value**
HGT	**SBP**	20.6 ± 8.745	16.4 ± 7.35	0.0354
	DBP	23.4 ± 6.801	20 ± 4.618	0.0381
CPT	**SBP**	23 ± 7.133	17.4 ± 5.168	0.003
	DBP	23.2 ± 7.067	17 ± 4.242	0.0153
LST	**SBP**	7.6 ± 3.502	7.2 ± 3.155	>0.05
	DBP	9 ± 3.915	7.8 ± 2.74	>0.05

HGT - hand grip test, CPT - cold presser test, and LST -lying to standing test. The data represents the delta values for SBP and DBP.

Hand grip test (HGT). The delta values of SBP20.6 ± 8.745 mmHg and DBP 23.4 ± 6.801 mmHg were reduced to delta values of SBP and DBP of 16.4 ± 7.35 mmHg and 20 ± 4.618 mmHgrespectively, after three weeks of meditation. This reduction was statistically significant (SBP p=0.0354)(DBP p=0.0381).

Cold Pressor test (CPT). The delta values of SBP 23 ± 7.133 mmHg and DBP 23.2 ± 7.067 mmHg were reduced to delta value of SBP and DBP of 17.4 ± 5.168 mmHg and 17 ± 4.242 mmHg , respectively after three weeks of meditation.This reduction was statistically highly significant in the case of SBP (p=0.003) and significant in the case of DBP, (p=0.0153).

Lying to standing test (LST). The delta values of SBP 7.6± 3.502 mmHg and DBP 9 ± 3.915 mmHg, were reduced to delta value, SBP and DBP of 7.2 ± 3.155 mmHg and 9 ± 2.74 mmHg, respectively. This reduction was statistically insignificant when the post-meditative delta value of SBP and DBP was compared with pre-meditative values (p>0.05).

Table: 5 Effect of Pranayama and Meditation on DBT & VM

Test	**Variables**	**Pre** **Mean ± SD**	**Post** **Mean ± SD**	**P value**
DBT	**E: I**	1.326 ± 0.092	1.358 ± 0.098	>0.05
VM	**VR**	1.555 ± 0.179	1.807 ± 0.184	< 0.0001

Deep Breathing Test (DBT) and Valsalva maneuver (VM).

Table 5.**Effect of Pranayama and Meditationon VR and E: Iratio shows** that the post-meditative value of VR (Valsalva ratio) 1.807 ± 0.184, when compared with pre-meditative values 1.555 ± 0.179, showed a highly significant change (p<0.0001).Whilethe post-meditative value of E: I (Expiratory Inspiratory ratio)) did not show any significant change (p>0.05) from their pre-meditative value.

DISCUSSION

The discussion interprets the results in the context of existing literature. The effects of meditation and pranayama on sympathetic and parasympathetic activity are discussed, along with comparisons to previous studies. The potential mechanisms underlying these effects are explored, emphasizing the importance of slow breathing and meditation techniques in modulating autonomic functions.

Our research found that meditation significantly reduced basal heart rate, systolic and diastolic blood pressure in the participants.

Yogic meditation and specific pranayama and relaxation techniques reduce O_2 consumption, metabolic rate, heart rate, pulse rate and respiratory rate, and increase CO_2 elimination measured immediately before, during, and after the meditation.[2]

RashmiVyas et al [10]also observed a significant decrease in diastolic blood pressure and heart rate in meditators.

Vernon A. Barnes et al.[11] studied the effect of meditation on blood pressure and heart rate in adolescents with high normal systolic blood pressure. After meditation, they observed a significant decrease in systolic and diastolic blood pressure.
In our study, we observed a significant decrease in NN50 and pNN50 in time domain measures of HRV.

Wu Sd and Lo Pc[12] studied the effects of HRV between inward-attention meditation and regular rest. They concluded that the difference in effects between the two groups was the decrease of LF/HF ratio and LF norm and the increase of HF norm, which suggested the benefit of a sympathovagal balance toward parasympathetic activity.

Shari A. Matzner[13] observed that in the time domain, the heart rate variance during meditation was significantly higher than before for all subjects. It reflects additional cyclic components present in heart rate modulation mechanisms during meditation. In the frequency domain, the total power in the sequences recorded during meditation was higher than the total power, and the additional power appeared in the LF band (0.04 – 0.15 Hz). It suggests that the equilibrium between the two autonomic nervous system branches is altered during meditation. It is contrary to our study, where we observed a non-significant decrease in the LF band, and we assume it could have been significant if our subjects had meditated for a longer duration.

In the present study, there was a significant decrease in both systolic and diastolic blood pressure in the Hand grip test and Cold pressor test. The study results of the Handgrip test parameter were lower among participants practicing yoga, and it was consistent with other studies done by Jyotsana et al[14] and Khanam et al.[15]At the same time, we didn't observe any significant change in Lying to standing test. Wealso observed a significant Valsalva ratio increase, but the E: I ratio was insignificant.

Ganguly et al[16]in their study also observed significant change in Valsalva ratio.

Mourya et al.[17]demonstrated the significance of slow breathingover quick breathing, where blood pressure response in the cold pressor test and hand grip, and S/L ratio, 30:15 ratio, E/I ratio demonstrated a noteworthy alteration in individualsundergoing the slow-breathing exercise.

However, they linked the mechanism, thatpeople who practiced the slow-breathing exercise improved both the sympathetic and parasympathetic reactivity.

Meditation and pranayama exerted significant effects on autonomic function, reducing sympathetic activity and enhancing parasympathetic tone.[18]Overall, yoga interventions can contribute to improving autonomic balance.

CONCLUSION:

Yoga, particularly meditation and pranayama, positively influences autonomic functions by reducing sympathetic activity and enhancing parasympathetic tone. These findings highlight the potential of yoga as a holistic approach to improve the autonomic balance towards parasympathetic foroverall well-being. Further research is warranted to explore the long-term effects of yoga interventions on autonomic functions and cardiovascular outcomes.

Conflict of Interest:
The authors had no conflict of interest to declare.

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