DOI: 10.5958/2319-5886.2014.00002.2

International Journal of Medical Research & Health Sciences

www.ijmrhs.com Volume 3 Issue 4 Coden: IJMRHS Copyright @2014 ISSN: 2319-5886

Received: 5th June 2014 Revised: 9th July 2014 Accepted: 11th Aug 2014

Research article

EFFECT OF SLOW RHYTHMIC VOLUNTARY BREATHING PATTERN ON ISOMETRIC HANDGRIP AMONG HEALTH CARE STUDENTS

*Rajajeyakumar M[1], Janitha A[2], Madanmohan[3], BalachanderJ[4]

[1]Assistant Professor, Department of Physiology, Chennai Medical College Hospital & Research Centre, Trichy
[2]Senior Medical Officer, Bharat Heavy Electrical Limited, Main Hospital, Trichy
[3]Professor& Head, Department of Physiology, Mahatma Gandhi Medical College & Research Centre, Pondicherry
[4]Professor & Head, Department of Cardiology, JIPMER, Pondicherry

*Corresponding author email:rajakumar60@gmail.com

ABSTRACT

Introduction: Hand grip strength is a widely used test in experimental and epidemiological studies. The measure of hand grip strength is influenced by several factors, including age; gender; different angle of the shoulder, elbow, forearm, and wrist; and posture**.** So we planned to study the effect of slow voluntary breathing exercise (Savitri Pranayam) on the various strengths of isometric hand grip (IHG) among young health care students. **Methods:** The present study was conducted on 60 volunteers 17-20 yrs. The subjects were randomly assigned to Pranayam and control groups. They were divided into two groups: control (n=30), Savitri (n=30 Savitri group were practiced slow yogic breathing for three months, Paired' test was done to compare the values within group and unpaired' test was done to compare the values between male and female subjects. **Results**: In Savitri Pranayam group, the blood pressure responses to IHG were higher in males, as compared to females. The rate pressure product (RPP) also decreased during IHG 60%. A decrease in SBP and DBP was observed at the end of the study period. Briefly, a gender difference in various parameters such as MAP, QTc existed in the control group at the beginning of the study and the differences persisted at the end of three months. **Conclusion:** Our study reported that slow Pranayam are known to enhance parasympathetic tone, produce a highly significant decrease in oxygen consumption and psychosomatic relaxation.

Keywords: SavitriPranayam, Hand grip strength, Yoga, Maximum Voluntary Contraction.

INTRODUCTION

Pranayama is a part of the ancient Indian art of yoga, which is the fourth step of Ashtangayoga. There are more than ten types of Pranayam. Some are on slow and soft rhythm and some are on fast and forceful rhythm.[1-4]Pranayama is a controlled and conscious breathing exercise which involves mental concentration. Hand grip strength (HGS) is a widely used test in experimental and epidemiological studies.[5] The measure of hand grip strength is influenced by several factors, including age; gender; different angle of the shoulder, elbow, forearm, and wrist; and posture.[6]The rate pressure product (RPP) is a reliable index of the myocardial oxygen consumption and the cardiac work and it correlates well with the myocardial oxygen consumption of normal subjects as well as of patients with angina pectoris.[7]Pranayam may influence the RPP by altering the preload and/or the after load. Handgrip

strength is an important test to evaluate physical fitness and nutritional status. HGS is a physiological variable that is affected by a number of factors, including age, gender, body size and posture etc.The endurance of the muscle refers to its capacity to withstand the power produced during the activity. Poor muscle strength has also been found to be associated with lower body weight and poor nutritional status is associated with poor HGS.[8]In view of this, the present work was planned, to study the effect of pranayama training on cardiovascular parameters like the heart rate, blood pressure, pulse pressure, mean arterial pressure and the rate pressure product.

OBJECTIVES

1. To assess the gender differences in HSG and endurance in young males and females.
2. To assess the correlations between various anthropometric and HGS on cardiovascular parameters in young males and females.

MATERIALS AND METHODS

The present study was conducted on 60 young right handed healthy volunteers after obtaining ethical clearance from the institutional Human Ethics Committee. The duration of the study period was between 2007 to 2008. Their age ranged between 17-20 years (17.65 ± 0.15), body weight between 46 - 65 kg (53.72 ± 2.28) and height between 146 – 173 cm (168.5 ± 1.12). All volunteers underwent ENT, mental or neurological examination at the beginning of the study to rule out any major illness. The subjects were randomly divided into control group and Savitri Pranayam group. Each group consisted of 30 volunteers and was further divided into two sub – groups based on gender. The participants were explained in detail about the study protocol and informed consent was obtained from them after meeting inclusion and exclusioncriteria.

Inclusion criteria: Subjects aged between 17 years and 20 years of either gender.

Exclusion criteria: 1. Subjects who practiced yogic techniques in past one year. 2. Subjects were unable to practice pranayama due to physical and other abnormalities. 3. Subjects with history of previous or current organic diseases. 4. Non vegetarian, a high-fat & energy, with regular physical activity.

Equipment used:

Blood pressure and heart rate were recorded with the subject seated comfortably, using the noninvasive automated BP monitor NIBP (Colin Press-Mate, Model BP 8800, Colin Corporation Inc., Japan). This measures BP by the oscillometric method. A standard adult-size cuff measures 23 cm by 12 cm was used for all subjects. Handgrip dynamometer (INCO India Ltd Ambala) was used to measure the muscle strength and endurance of the upper limbs, according to the technique described and validated by Madanmohan *et al 2005.*[9]

IHG at 10% of MVC: This test assesses the sympathetic reactivity of an individual. Using a handgrip dynamometer, the volunteer was asked to do maximum voluntary contraction (MVC) for a few seconds. After five minutes rest, they were requested to maintain 10% of MVC for up to one minute while blood pressure was monitored in the non – exercising arm. The difference between the diastolic blood pressure just before release of handgrip was taken as the measure of the response.

IHG at 30% of MVC: The procedure was same as that of IHG 10% of MVC; however, instead of 10% the volunteer was asked to maintain 30% of his MVC for a period of one minute.

IHG at 60% of MVC: Here, the volunteer was asked to maintain 60% of his MVC for a period of one minute.

Following these recordings, the volunteers were trained in Savitri Pranayam and instructed to refrain from any yogic practice or exercise depending on whether they belonged to group II (Savitri group) or group I (Control group) Each group consisted of 30 volunteers and was further divided into two sub – groups based on gender. After explaining the procedure to the study subject and giving a demonstration, they were asked to hold the handgrip dynamometer in the dominant hand in sitting position. [10] The forearm was extended over a table and elbow flexed at 90°. Subjects were asked to hold the dynamometer and the second phalanx was against the inner stirrup where they asked to grip the dynamometer handle with as much force. The handgrip muscle strength was recorded in kilograms as indicated by the pointer on the dynamometer. Three recordings were taken with a gap of two minutes between each effort and the maximum value was recorded for the analysis.

Parameters recorded:

The following parameters were recorded in all volunteers at the beginning and end of three months study period.

1. Anthropometry: BMI
2. Heart rate (HR)
3. Systolic blood pressure (SBP)
4. Diastolic blood pressure (DBP).
5. Rate Pressure product (RPP)
6. QTc interval

Procedure: Subjects were asked to report to the recording laboratory between 4-6 pm. In general, yoga practice is recommended in the morning or the early evening. However, we should ensure that 3.5 to 4 Hrs.gap was maintained after Lunch. Evening yoga practice can help calm the nervous system, reduce physical, mental tension, unwind after a long day and can even help with maintain normal sleep pattern. Basal parameters like HR & BP were recorded by using NIBP after 15 min rest in sitting posture. The participant's basal values (pre-yoga) were recorded. The Pranayam group was taught Savitri Pranayam by trained yoga teacher and practices same under our direct supervision for 30 min per day, thrice per week for a total duration of 12 weeks. They were performed Pranayam for 5 minutes, followed by 5 min rest. Three such cycles were practiced by subjects. Control group were not taught and did not practice Savitri pranayam.

Procedure for Savitri Pranayam[10]

Savitri Pranayam was done by subject in sitting posture (with erect spine) in a well-ventilated room. It is ensured prior to the breathing exercise that there is no nasal obstruction due to any medical problem like a common cold. The exercise was performed in as follows:

Subject is asked to breathe slowly, uniformly and deeply with a ratio of 2:1:2:1 between inspiration (purak) held in (kumbhak), expiration (rechak) and held out (shunyak) phases. Our volunteers performed the pranayam with a respiratory rate of three per minute. The above mentioned parameters were recorded in all volunteers of both control and savitri pranayam groups at the end of three months study period.

Calculation of R- R interval: ECG was acquired at a rate of 1000 samples per second using the BIOPAC MP 100 system and the BIOPAC AcqKnowledge software 3.7.1 (BIOPAC Inc., USA) for at least 330 seconds. ECG was examined for artifacts and ectopics and if present they were edited out and the preceding and successive noise-free segments were joined by linear interpolation with NN intervals (i.e. Normal-to-normal RR intervals). When atrial or ventricular premature complexes were encountered, the preceding and the succeeding intervals were excluded. The edited ECG was processed using an R-wave detector to obtain an RR interval tachogram. A detailed account of techniques of R- R interval analysis is mentioned in the Task Force Report of the European Society of Cardiology, 1996.

Calculation of QTc: QT & QTc intervals were analyzed by lab chart pro 6 software (AD Instruments, Australia). The files were recorded from the BIOPAC AcqKnowledge software 3.7.1 imported into lab chart pro 6 software. The ECG Beat Classifier enables the selection and removal of unsatisfactory beats or groups of beats. Once the appropriate setting has been chosen, the ECG Analysis Module automatically detects the ECG beats according to the ECG settings. The MLS360/6 ECG Analysis Module for Windows automatically detects and reports QT and QTc intervals, either online or offline. The QTc interval was calculated by applying Bazzet formula: $QTc = QT/\sqrt{RR}$. The ECG Analysis Module averages any chosen ECG beats within an ECG recording. The number of ECG beats averaged and analyzed together the mean QTc interval was obtained from the same software. The ECG Table View logs and displays selected ECG parameters. Available parameters are chosen in the ECG Table View dialog. Values for each ECG average are automatically logged to the ECG Table View and can be added to the Data Pad (Lab Chart's internal spreadsheet) or the parameters can also be exported to graphing or statistical programs for further analysis.

Calculation of RPP: RPP was calculated ($RPP = SP \times HR / 100$) as the product of systolic pressure and heart rate It has been shown to correlate with myocardial oxygen consumption during exercise in patients with angina pectoris.[11]

Data analysis: Data was analyzed using the SPSS statistical program (IBM SPSS statistics 21). An unpaired t test was done to compare parameters between male and female subjects and a paired t test to compare values at the beginning and the end of the study period. P value less than 0.05 was considered as significant.

RESULTS

Control group*:* The control group was not subjected to any Pranayam training. Tables 1, 2 give various parameters measured in the control group at the beginning and end of three months study period. All the parameters measured during experimental conditions were similar at the beginning and end of the three months study period.

Table 1: Parameters of group I (control male) subjects at the beginning and end of the three months study period.

Parameter		Beginning	End	P value
Rest	**HR**	73.80 ± 2.11	72.73 ± 1.58	0.699
	SBP	121.80 ± 2.1	121.60 ± 1.94	0.946
	DBP	74.26 ±1.71	74.20 ± 1.39	0.974
	MAP	90.11 ± 1.2	90.00 ± 1.03	0.946
	RPP	89.74 ± 2.7	88.39 ± 2.26	0.718
	QTc	0.342 ± 0.00	0.334 ± 0.003	0.352
IHG 10%	**HR**	78.86 ± 2.0	78.66 ± 1.94	0.959
	SBP	127.20 ± 2.0	127.87 ± 1.71	0.801
	DBP	76.66 ± 1.7	76.20 ± 1.63	0.811
	MAP	93.51 ± 1.3	93.42 ± 1.26	0.958
	RPP	100.31 ± 3.0	100.58 ± 2.81	0.96
	QTc	0.339 ± 0.00	0.342 ± 0.005	0.566
IHG 30%	**HR**	83.20 ± 2.2	83.66 ± 2.28	0.914
	SBP	133.87 ± 2.1	133.27 ± 1.43	0.802
	DBP	81.46 ± 1.41	80.93 ± 1.22	0.663
	MAP	98.93 ± 1.07	98.37 ± 0.88	0.667
	RPP	111.32 ±3.18	111.69 ± 3.70	0.952
	QTc	0.336 ± 0.006	0.337 ± 0.007	0.858
IHG 60%	**HR**	87.60 ± 2.26	88.26 ± 2.15	0.875
	SBP	137.40 ± 0.83	137.47 ± 0.90	0.961
	DBP	84.60 ± 1.22	84.33 ± 1.05	0.847
	MAP	102.20 ± 0.88	102.04 ± 0.75	0.875
	RPP	120.29 ± 3.18	121.32 ± 3.70	0.856
	QTc	0.354 ± 0.01	0.356 ± 0.01	0.881

In contrast, BMI values were in the males (23.11±0.508 to 23.18±0.514, p≤0. 67) and females (21.74±0.623 to 21.91±0.667, p≤0. 33). In contrast, Pranayam group, they were attained statistical significance at the beginning and the end of the study. The values were in the males (22.64±0.356 to 22.17±0.377, p≤0.001) and females (23.12±0.516 to 22.82±1.91, p≤0.019).

Savitri group: The volunteers of this group received three months training in Savitri Pranayam. Tables 3, 4shown various parameters recorded in male and female volunteers of Savitri group at the beginning and end of three months study period. In male subjects, QTc was increased at the end of the study during rest from a value of 0.351 ± 0.004 to 0.327 ± 0.005, the increase being statistically significant ($p \leq 0.01$). During IHG 60% the RPP decreased from an initial value of 119.32 ± 2.93 to 111.75 ± 2.95, the decrease being statistically significant ($p \leq 0.01$).

Table 2: Parameters of group II (control female) subjects at the beginning and end of the three months study period

Parameter		Beginning	End	P value
Rest	**HR**	75.93 ± 1.82	76.53 ± 1.81	0.839
	SBP	122.33 ± 1.47	123.47 ± 1.25	0.453
	DBP	69.26 ±1.37	69.66 ± 1.02	0.83
	MAP	86.95 ± 1.00	87.60 ± 0.97	0.615
	RPP	92.86 ± 1.00	94.43 ± 0.97	0.67
	QTc	0.368 ± 0.009	0.366 ± 0.008	0.924
IHG 10%	**HR**	81.40 ± 1.75	81.86 ± 1.78	0.868
	SBP	127.50 ± 1.38	128.70 ± 1.23	0.458
	DBP	74.07± 1.63	75.20 ± 1.47	0.599
	MAP	91.86 ± 1.09	93.04 ± 0.94	0.503
	RPP	103.67 ± 2.24	105.33 ±2.31	0.64
	QTc	0.351 ± 0.006	0.354 ± 0.005	0.662
IHG 30%	**HR**	84.60 ± 1.72	85.26 ± 1.69	0.816
	SBP	132.70 ±1.47	133.90 ± 1.32	0.621
	DBP	78.73 ±1.61	80.20 ± 1.41	0.534
	MAP	96.73 ± 1.26	98.11 ±1.13	0.528
	RPP	112.22 ± 2.38	114.20 ± 2.52	0.649
	QTc	0.367 ± 0.006	0.361 ± 0.007	0.627
IHG 60%	**HR**	87.86 ± 1.61	88.8 ± 1.55	0.723
	SBP	136.40 ± 1.51	138.10 ± 1.32	0.496
	DBP	81.47 ± 1.76	82.07 ± 1.62	0.838
	MAP	99.77 ± 1.46	100.8 ± 1.33	0.716
	RPP	119.84 ± 2.54	122.64 ± 2.35	0.526
	QTc	0.356 ± 0.008	0.365 ± 0.009	0.434

Table 3: Parameters of group II (Savitri male) subjects at the beginning and end of the three months study period

Parameter		Beginning	End	P value
Rest	**HR**	68.80 ± 1.22	65.933 ± 1.48	0.078
	SBP	116.26 ± 2.62	111.80 ± 1.79	0.243
	DBP	63.87 ± 2.75	62.66 ± 1.53	0.689
	MAP	82.06 ± 2.16	79.04 ± 1.51	0.252
	RPP	79.89 ± 1.96	76.07 ± 2.81	0.285
	QTc	0.351 ± 0.004	0.32±0.005**	0.924
IHG 10%	**HR**	73.80 ± 1.65	72.00 ± 1.40	0.491
	SBP	131.33 ± 1.83	127.87 ± 2.99	0.318
	DBP	77.20 ± 2.04	74.80 ± 3.28	0.587
	MAP	95.24 ± 1.66	92.49 ± 3.07	0.47
	RPP	96.92 ± 1.96	92.17± 3.07	0.225
	QTc	0.343 ± 0.005	0.329 ± 0.009	0.293
IHG 30%	**HR**	76.46 ± 1.80	75.60 ± 1.61	0.717
	SBP	135.66 ± 2.39	132.20 ± 3.05	0.27
	DBP	79.00 ± 3.55	75.40 ± 3.38	0.446
	MAP	97.88 ± 3.05	94.33 ± 3.12	0.381
	RPP	104.00 ± 3.75	100.20 ± 3.25	0.347
	QTc	0.355 ± 0.008	0.345 ± 0.011	0.418
IHG 60%	**HR**	86.60 ± 1.89	83.00 ± 1.43	0.9
	SBP	137.86 ± 2.05	134.60 ± 2.51	0.273
	DBP	82.06 ± 1.74	78.40 ± 2.67	0.32
	MAP	100.66 ± 1.49	97.13 ± 2.31	0.213
	RPP	119.32 ± 2.93	111.7± 2.95*	0.028
	QTc	0.365 ± 0.008	0.345 ± 0.007	0.117

Table 4: Parameters of group II (Savitri female) subjects at the beginning and end of the three months study period

Parameter		Begining	End	P value
Rest	**HR**	77.00 ± 1.00	72.40 ± 1.21**	0.006
	SBP	114.80 ± 2.62	111.26 ± 2.93	0.426
	DBP	67.66 ± 2.83	63.40± 2.10	0.28
	MAP	88.20 ± 3.71	79.35 ± 2.15*	0.042
	RPP	88.51 ± 2.61	80.73 ± 2.82	0.065
	QTc	0.375 ± 0.005	0.352 ± 0.005*	0.014
IHG 10%	**HR**	86.80 ± 2.58	82.66 ± 1.75	0.188
	SBP	128.53 ± 2.84	120.86± 2.90*	0.016
	DBP	79.66 ±3.65	71.80 ± 2.67*	0.021
	MAP	97.33 ± 3.00	87.13± 2.36**	0.002
	RPP	111.69 ± 4.40	97.51± 3.78**	0.004
	QTc	0.370 ± 0.008	0.354 ± 0.006	0.165
IHG 30%	**HR**	92.20 ± 2.09	87.80 ± 1.97	0.154
	SBP	131.06 ± 2.58	124.53 ± 3.47	0.152
	DBP	77.53 ± 2.79	76.13 ± 3.88	0.787
	MAP	95.37 ± 2.41	92.26 ± 3.57	0.503
	RPP	120.93 ± 3.85	109.57 ± 4.46	0.09
	QTc	0.379 ± 0.009	0.360 ± 0.006	0.066
IHG 60%	**HR**	87.26 ± 2.02	89.13 ± 2.04	0.57
	SBP	126.13 ± 3.54	128.53 ± 3.73	0.647
	DBP	75.13 ± 3.58	74.60 ± 2.54	0.899
	MAP	94.66 ± 4.27	92.57 ± 2.74	0.663
	RPP	109.88 ± 3.64	114.90 ± 4.78	0.403
	QTc	0.361 ± 0.008	0.369 ± 0.005	0.29

[$]Values are expressed as mean ± SEM.

Paired t test was applied to compare the parameters at the beginning and end of the study. HR – heart rate,SBP – systolic blood pressure, DBP – diastolic blood pressure, MAP – mean arterial pressure, RPP – rate pressure product,QTc – corrected QT interval, IHG – isometric handgrip.

*P≤0.05.,**P≤0.01,***P≤0.001

To summarize, The RPP was also decreased during IHG 60%. The female subjects of Savitri group exhibited a similar trend of decreasing, HR, MAP & QTc during rest. Briefly, a gender difference in various parameters such as MAP, QTc existed in the control group at the beginning of the study and the differences persisted at the end of three months in the group. In the Savitri group, a similar trend was evident at the beginning and the end of the study. In savitri pranayam group, the blood pressure responses to IHG were higher in males, as compared to females.

DISCUSSION

In our control group of male as well as female volunteers the recorded cardiovascular parameters were similar and BMI of both genders were not attained statistical significance at the beginning and the end of the three months study period. BMI was significantly decreased in both male and female Pranayam groups in compared with the control group. Regular practice of Pranayam in the right manner can help increase the metabolism and helps in burning off more calories. It is important to realize that the process of weight loss through Pranayama or most other yoga forms slow and gradual. However, when pranayama is modified by several levels, it can help facilitate weight loss at a faster rate.

Savitri Pranayam group: Savitri Pranayam is a slow type of breathing, known to enhance parasympathetic tone. The results of this group are in accordance with this. The heart rate and blood pressure during rest was lower in male as well as female volunteers, but attained statistical significance only in the latter. In general, the rise in HR & BP in response to IHG was less at the end of the study period. This may be due to the improved autonomic tone resulting in an increased parasympathetic drive, calming of stress responses, neuroendocrine release of hormones and thalamic generators. This blunting of the presser response was more prominent during IHG 10% of MVC and more so in the female group. The values in the male volunteers did not attain statistical significance. This is consistent with earlier reports from our laboratory that Savitri Pranayam can produce a highly significant decrease in oxygen consumption and psychosomatic relaxation. The RPP was also less after Savitri Pranayam training in both male and female subjects. RPP is an index of myocardial oxygen consumption and load on the heart[10,-12].This interesting finding of ours has great applied value as this indicates that Savitri pranayam can be used as an effective technique to reduce load on the heart during stressful situations. Deep breathing reduced blood pressure in male as well as female subjects after Savitri pranayam.

At the beginning of the study, the resting HR, RPP, and QTc were significantly higher in females (N=15) as compared to males. During IHG exercise of various grades of all values was higher in males (N=15) volunteers, but the SBP attained statistical significance. At the end of the study in this group during rest, HR and QTc were higher in females as compared to males, but the values were less as compared to the values at the at the beginning of the study period. Pramnic et al (2009)have reported that

pranayama increases frequency and duration of inhibitory neural impulses by activating pulmonary stretch receptors during above tidal volume inhalation as in Hering Bruer reflex, which bring about withdrawal of sympathetic tone in the skeletal muscle blood vessels, leading to widespread vasodilatation, thus causing decreases blood pressure and increases heart rate.[11] The gender difference in various parameters during IHG exercise of different grades existed after the three months study period. This is in agreement with the reports of Madanmohan et al (1983) that savitri pranayam (a slow, deep and rhythmic breathing) produces a highly significant decrease in HR and SBP.[12,13] Also Sharma et al, (2007) have reported that isometric exercise induced rise in is blunted and a progressively lower percentage increase is observed in a person practicing shavasana.[14-20]

CONCLUSION

Our study has revealed a number of important facts which can have important therapeutic implications. The fact that Savitri Pranayam enhances parasympathetic activity has been reproduced first time in our study. Three month training and practice in yogic- type breathing is sufficient to induce beneficial change in autonomic functions, ECG parameters and reaction time. The gender difference was evident in all the parameters measured. Our findings were in accordance with previous studies.

Therefore yogic breathing practices can be prescribed to both healthy people and those with cardiovascular autonomic dysfunction. Moreover, specific breathing techniques can be advised depending on whether an individual has high sympathetic or parasympathetic tone. Hand grip strength is currently used worldwide because it is a relatively cheap test that gives practical information on muscle, nerve, bone, or joint disorders.

LACUNAE & RECOMMENDATIONS:

The present study requiring a further randomized controlled trial and a follow-up to determine the impact of diet on Pranayam training. To standardize the procedure and increase the reliability, as otherwise the measurement error may be too large to detect actual changes in strength. It must be borne in mind that different kinds of dynamometers and postures might change the results. Moreover, hand grip strength is associated with bone mineral density, impaired cognition, nutritional status and cardiovascular disease risk factors[20]. Therefore, from a public health perspective, it is important to standardize the procedure and increase the reliability. It must be borne in mind that different kinds of dynamometers and postures might change the results.

ACKNOWLEDGMENT

My sincere thanks to Dr Amudharaj D, Assistant professor, Department of Physiology, Aarupadai Veedu Medical College & Hospital Pondicherry, helping me for providing the statistical analysis.

Conflict of interest: None

Source of funding: Nil

REFERENCES

1. AnkadRoopa B, AnkadBalachandra S, HerurAnitha. Effect of short term Pranayama and meditation on Respiratory parameters in healthy individuals. International Journal of Collaborative Research on Internal Medicine & Public Health. 2011;3(6): 430-36.
2. ShirleyTelles, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. Indian J PhysiolPharmacol. 1994; 38(2):133-7.
3. Nagendra R.Yoga for promotion of positive health. 4th ed. Bangalore: Swami Vivekananda Yoga Prakashana.2006; 20:98–104.
4. Chanavirut R, Khaidjapho K, Jaree P, Pongnaratorn P. Yoga exercise increases chest wall expansion and lung volumes in young healthy Thais. Thai journal of Physiological Sciences, 2006; 19(1):1-7
5. Kato T, Miyamoto K, Shimizu K. Postural reaction during maximum grasping maneuvers using a hand dynamometer in healthy subjects. Gait Posture 2004; 20(2):189 –195.
6. Pramanik T, Pudasaini B, Prajapati R. Immediate effect of the slow pace breathing exercise, Bhramari pranayama on the blood pressure and the heart rate. Nepal Med Coll J 2010; 12(3) 154-7.
7. Gobel FL, Nordstrom LA, Nelson RR, Jorgensen CR, Wang Y. The rate-pressure-product as an index of myocardial oxygen

consumption during exercise in patients with angina pectoris.Circulation 1978;57(3):549-56.
8. Norman K, Stobäus N, Gonzalez MC, Jörg-Dieter Schulzke, Pirlich M, Hand grip strength: Outcome predictor and marker of nutritional status. Clinical Nutrition 2011; 30(2):135-42.
9. Madanmohan, Prakash ES, Bhavanani AB. Correlation between short – term heart rate variability indices and heart rate, blood pressure indices, pressure reactivity to isometric handgrip in healthy male subjects. Indian J PhysiolPharmacol. 2005; 49(2): 132 – 38.
10. Swati Shah, PradeepNahar, SavitaVaidya, SundeepSalvi. Upper limb muscle strength & endurance in chronic obstructive pulmonary disease.Indian J Med Res. 2013; 138(4): 492–496.
11. Pramanik T, Sharma HO, Mishra S, Mishra A, Prajapati R, Singh S.Immediate effect of slow pace bhastrika pranayama on blood pressure and heart rate.JAltern Complement Med. 2009;15(3):293-5.
12. Madanmohan, Rai UC, Balavittal V, Thombre DP, Swami Gitanada. Cardio respiratory changes during Savitri Pranayam and Shavasan.*The Yoga review* 1983; 3(1): 25-34.
13. Brown RP, Gerbarg PL. SudarshanKriya yogic breathing in the treatment of stress, anxiety, and depression: part I-neurophysiologic model. J Altern Complement Med. 2005; 11(1):189–201.
14. Sharma G, Maharajan KK, Sharma L. Shavasana – Relaxation technique to combat stress. *Journal of* Body work and Management Therapies 2007; 11(2); 173 – 80.
15. Sharma VK, Trakroo M, Subramaniam V, Rajajeyakumar M, Bavavani AB, Sahai A. Effect of fast and slow pranayam on perceived stress and cardiovascular parameters in young health-care students.Int J Yoga 2013; 6(2):104-10.
16. Rajajeyakumar M, Bhattacharjee M, Madanmohan. Balachander J. Effect of slow and fast pranayams on gender specific difference in QTc interval of healthy young adults.Int. Res J Pharm. App Sci., 2013; 3(5): 266-270.
17. Vivek Kumar Sharma, Rajajeyakumar M, VelkumaryS.Senthil Kumar Subramanian. Effect of Fast and Slow Pranayama Practice on Cognitive Functions in Healthy Volunteers. Journal of Clinical and Diagnostic Research. 2014;8(1): 10-13.
18. Dinesh Thangavel, Girwar Singh Gaur, Vivek Kumar Sharma, AnandaBalayogiBhavanani, Rajajeyakumar M., Syam Sunder A. Effect of Slow and Fast Pranayama Training on Handgrip Strength and Endurance in Healthy Volunteers. Journal of Clinical and Diagnostic Research. 2014;8(5): BC01-BC03.
19. Alperovitch-Najenson D, Carmeli E, Coleman R, Ring H. Handgrip strength as a diagnostic tool in work-related upper extremity musculoskeletal disorders in women. ScientificWorld Journal 2004;4(3):111–117.
20. Raji MA, Kuo YF, Snih SA, Markides KS, Peek MK, Ottenbacher KJ. Cognitive status, muscle strength, andsubsequent disability in older Mexican Americans. J Am GeriatrSoc 2005;53(9):1462–68.