Effect of Pranayama On

Stress and Cardiovascular Autonomic Tone & Reactivity

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Abstract : BACKGROUND :The stress either physical or mental, leads to cardiovascular morbidity. Newly admitted medical students are likely to be exposed to various stresses like change of environment, demanding medical education and different teaching protocol in a medical college. Pranayama is known since ancient times to relieve stress and stabilize autonomic function of the body. METHOD: The subjects were first M.B.B.S students and the sample size was 59 consisting of 27 males and 32 females. The group of students thus selected was briefed about the study. After the orientation session, informed written consent was taken, stress questionnaire was put and the autonomic function tests were done. This was followed by practice of Pranayama for 2 months, 1 hour/day for 5 days/week and again stress questionnaire was put and the autonomic function tests were performed on the study group. RESULTS AND ANALYSIS: The above tests were done before and after the practice of Pranayama. The results obtained were analyzed using SPSS software. CONCLUSION: The stress level has reduced after 2 months of practicing various pranayama as evident by decrease in total stress score which is highly significant. VLF and LF in n.u have reduced significantly after practice of pranayama signifying reduction in sympathetic drive to heart. HF in n.u has increased significantly after practice of pranayama for 2 months showing the increase in parasympathetic output to the heart. LF/HF ratio reduced significantly after 2 months of practice of pranayama indicating a better sympatho vagal balance with resting balance tilting toward better parasympathetic control

Key-words: Heart rate variability, stress, low frequency, high frequency, very low frequency,

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INTRODUCTION: Today's ever-changing, technologically advanced & highly competitive environment causes persistent stress to humans. Stress, according to health experts will cause more health problems than ever before, as it is characterized by change in set point of hypothalamopituitary axis activity leading to stimulation of autonomic nervous system resulting in immediate effects on heart rate, blood pressure, temperature, respiratory rate, plasma catecholamine and corticosteroids. Stressors can be physical conditions such as heat or inflammation, exercise, etc. or psychological like exam, interview, etc. Acute stresses improve the performance by increasing sympathetic discharge for a short time but chronic stress increases sympathetic discharge for longer time. Sympathetic over activity for longer time is known to be associated with hypertension and

increase in cardiovascular morbidity and mortality. The changes produced by physical stress such as effect of exercise on various physiological parameters are well studied but impacts of psychological stressors are less studied. The studies so far on psychological[1, 2] stresses are largely restricted to laboratory using questionnaire. The studies on real life stressor are also very limited.

Several studies both from West [3-6] and from Asia have reported that medical training is highly stressful particularly for those who are beginning their medical education. It is likely that sources of stress are common across culture [7]. Studies have shown link between stress and cardiovascular disease [8]. Psychological stress is a risk factor for hypertension and coronary artery disease. Its physiological mechanism may involve excessive sympathetic activation [9]. It has been suggested that power spectral analysis of heart rate variability (HRV) might

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offer clue to links between psychosocial risk factors and cardiovascular morbidity [10]. Power spectral analysis reveals three spectral components: The very low frequency (VLF) (<0.004 Hz), low frequency LF (0.004-0.15 Hz) and high frequency HF (0.15-0.4 Hz). HF is largely a function of parasympathetic activity to heart while LF component normalized for1total power is used as a representative index of sympathetic activity to the heart [12].

There are many stress busters in today's era but the ancient and most balanced stress relieving cum autonomic stability achieving method is yoga. In yoga, Pranayama is known to modulate autonomic output. The combination of various types of pranayama helps in achieving and maintaining autonomic balance between two components (sympathetic and parasympathetic) of autonomic nervous system. Pranayama [13] forms fourth limb of classical Patanjali's Ashtanga yoga (eight fold sadhana).

From literature it appears that stress either physical or mental, leads to cardiovascular morbidity. Newly admitted medical students are likely to be exposed to various stresses like change of environment, demanding medical education and different teaching protocol in a medical college. Pranayama is known since ancient times to relieve stress and stabilize autonomic function of the body. Hence it was decided to study the effect of Pranayama on first M.B.B.S newly admitted medical students by comparing certain parameters.

MATERIAL AND METHODS: The subjects were first M.B.B.S students and the sample size was 59 consisting of 27 males and 32 females who had joined their first M.B.B.S in July and enrolled for the study within one month after joining first M.B.B.S. The protocol was approved by ethical committee of the Institute. The students were recruited in the study, then history taking and clinical examination was done keeping in mind following inclusion and exclusion criteria.

INCLUSION CRITERIA: FIRST M.B.B.S newly admitted students to the medical college of comparable socioeconomic status, psychosocial nature and dietary habit. They should voluntarily participate and undergo Pranayama training every evening for one hour as taught by the instructor.

EXCLUSION CRITERIA: They should not be practicing any known stress relieving or relaxation technique. They should not be having any drugs or beverages in quantity which affect the autonomic nervous system like anticholinergic drugs. They should not be having any major illness which is known to affect the autonomic nervous system.

The group of students thus selected was briefed about the study. After the orientation session, informed written consent was taken, stress questionnaire was put. The pretested and prevalidated stress questionnaire of questions was used. The scoring system has 5 points starting from 1 i.e. almost never to 5 i.e. most of the time. The maximum possible score was 5 and minimum possible score was 1 for any given question. The subjects were instructed to mark under only one point and attempt all the questions. The autonomic function tests were done. This was followed by practice of Pranayama [10] for 2 months, 1 hour/day for 5 days/week and again stress questionnaire was put and the autonomic function tests were performed on the study group. The Pranayama practiced were Kapalabhati, External Kumbhaka (Bahya), Easy Comfortable Pranayama (Sukha Purvaka), Surya Bhedan, Ujjayi, Sitkari and Sitali. The subjects underwent all the autonomic function tests on the same day and the order of tests was kept constant for all the subjects throughout the study. The autonomic function tests in female subjects were done on 5th or 6th day of the menstrual cycle.

Following Autonomic Function Tests was done using standard procedure[11, 13, 14, 15]
- Autonomic tone was measured using Heart Rate Variability
- Autonomic reactivity was measured by following tests
  - Handgrip Dynamometer test
  - Cold pressor test
  - Lying down to standing test

RESULTS : Demographic profile of the study group is shown in Table 1 which shows that there are maximum students in age group 17-18 years i.e. 34(57.63%) but maximum males belong to age group of 19 -20 years and females belong to 17-18 years.

Table 1: Age and sex wise distribution of cases in study group

Age (Yrs)	Sex		Total
	Male	**Female**	
17 – 18	7 (11.86)	27 (45.76)	34 (57.63)
19 – 20	19 (32.20)	5 (8.47)	24 (40.68)
21 – 22	1 (1.69)	0 (0)	1 (1.69)
Total	**27 (45.76)**	**32 (54.24)**	**59 (100)**

Table 2 below shows pre and post intervention answer to questionnaire used to measure subjective stress level in the study group

Table 2:

Particular	Pre Mean ± SD (n=59)	Post Mean ± SD (n=59)	WSRT	P Value
Do you get on well with your coworker?	4.42 ± 0.86	4.61 ± 0.56	1.73	0.083 NS
Do you let others know how are you feeling?	3.17 ± 1.04	3.46 ± 1.13	1.83	0.067 NS
Do you suffer from constipation or diarrhea?	1.83 ± 0.93	1.47 ± 0.68	3.23	0.001**
Do you get jealous of others?	1.93 ± 0.91	1.69 ± 0.91	2.28	0.022*
How often do you catch cold?	3.10 ± 1.23	2.90 ± 1.21	1.25	0.21 NS
Do you crave sweet things to eat?	3.19 ± 1.09	3.12 ± 1.10	0.69	0.49 NS
How often do you suffer from headache?	2.76 ± 1.09	2.42 ± 1.09	2.48	0.013*
When you are ill does it take long to get over it?	2.31 ± 1	2.19 ± 1.04	1.02	0.31 NS
Are you quick to anger?	3.03 ± 1.33	2.66 ± 1.24	2.21	0.027*
Do you feel you are under too much pressure?	3.31 ± 0.95	2.83 ± 1.02	3.25	0.001**
Do you feel refreshed at beginning of the day?	3.92 ± 1	3.90 ± 1.16	0.27	0.79 NS
How often do you feel lonely?	2.83 ± 1.13	2.53 ± 1.07	2.23	0.03*
Do you drink alcohol?	1 ± 0	1.02 ±	1	0.32
		0.13		NS
Does your heart pound?	2.75 ± 0.96	2.34 ± 1.04	3.01	0.003*
Do you suffer with difficulty in sleeping?	1.88 ± 1.13	1.66 ± 0.90	1.91	0.05*
When conflicts do you overreact?	2.39 ± 1.16	2.19 ± 0.86	1.15	0.25 NS
Do you have difficulty in concentrating?	3.37 ± 0.93	2.90 ± 1.11	3.37	0.001**
Do you have allergy flare up?	1.80 ± 1.01	1.47 ± 0.82	2.65	0.008*
Do you sweat excessively?	2.27 ± 1.22	2.08 ±1.18	2.29	0.02 NS
Are you happy?	4.02 ± 0.94	4.39 ± 0.79	3.84	0.00001**

*Significant, **Very Significant, NS- Not Significant

Table 3 shows total stress score obtained before and after pranayama expressed as mean ± S.D and t test is applied.

Table 3: Analysis of total stress score and various tests for autonomic function

Particular	Pre Mean ± SD (n=59)	Post Mean ± SD (n=59)	t Test	P Value
Total score	52.24 ± 6.14	49.17 ± 5.90	4.19	0.0001**
Max. RR int.	0.93 ± 0.12	0.95 ± 0.15	1.05	0.29 NS
Min.. RR int.	0.57 ± 0.08	0.56 ± 0.08	0.79	0.43 NS
Mean. RR int.	0.77 ± 0.09	0.79 ± 0.18	0.90	0.37 NS
Max. /Min. RR int.	1.65 ± 0.27	1.70 ± 0.30	1.19	0.24 NS
Max. HR	107.15 ± 13.67	109.61 ± 17.10	1.04	0.30 NS
Min. HR	65.37 ± 8.47	64.63 ± 8.49	0.59	0.55 NS
Mean HR	78.83 ± 10.10	79.86 ± 9.75	0.79	0.44 NS
SDNN	61.51 ± 27.35	66.40 ± 27.34	1.33	0.19 NS
RMSSD	67.74 ± 33.98	76.38 ± 32.02	1.69	0.09 NS
NN50	109.54 ± 66.86	126.71 ± 73.58	1.78	0.08 NS
pNN50	30.41 ±	33.51 ±	1.22	0.23 NS

	17.75	20.03		
LF in n. u.	63.27 ± 12.88	53.03 ± 13.58	6.78	0.0001 **
HF in n. u.	36.79 ± 12.88	46.95 ± 13.56	6.76	0.0001 **
LF/HF	2.10 ± 1.19	1.32 ± 0.71	6.68	0.0001 **
VLF	66.80 ± 23.39	58.01 ± 24.33	2.91	0.005 *
IHT Increase DBP (mm Hg)	19.42 ± 9.22	22.98 ± 8.32	6.27	0.0001 **
CPT Increase DBP (mm Hg)	10.68 ± 3.94	11.90 ± 3.90	4.53	0.0001 **
LTS Decrease SBP (mm Hg)	8.71 ± 1.43	6.54 ± 1.43	19.51	0.01

*Significant, **Very Significant, NS- Not Significant
Power spectral band are calculated in ms2 (absolute power) and in normalized power (n.u.). For example to normalize unit of LF it is calculated by the formula: (LF/total power-VLF) x100. The normalization emphasizes the controlled and balanced behavior of 2 parts of autonomic nervous system.

Table 4 shows correlation between total stress score and LF in n.u before and after pranayama in the study group.

Table 4: Correlation between total stress score and various tests for autonomic functions

Correlation between	r Value	P Value
Total score and LF in n. u. (Pre)	0.42	<0.001**
Total score and LF in n. u. (Post)	0.24	<0.05 *
Total score and HF in n. u. (Pre)	-0.42	<0.001**
Total score and HF in n. u. (Post)	-0.24	<0.05 *
Total score and LF/HF ratio (Pre)	0.36	<0.01 *
Total score and LF/HF ratio (Post)	0.22	>0.05 NS

*Significant, **Very Significant, NS- Not Significant
{n.u.-normalized power , Max. RR int.- maximum RR interval,Min.. RR int.- minimum RR interval, Mean. RR int.-mean RR interval,Max. /Min. RR int.- maximum divided by minimum RR interval,Max. HR maximum heart rate, Min. HR- minimum heart rate, Mean HR- mean heart rate, SDNN-Standard deviation of the RR intervals, RMSSD- The root square of the mean of the squares of differences between adjacent RR intervals.,NN50- Number RR interval differences=50 ms, pNN50- Percentage of NN50, LF in n. u. - Low Frequency(LF), HF in n. u.- High Frequency(HF), LF/HF- Low Frequency(LF)/High Frequency(HF), VLF- Very low Frequency(VLF, IHT Increase DBP (mm Hg)- isometric handgrip dynamometer(IHT), CPT Increase DBP (mm Hg)- cold pressor test(CPT), LTS Decrease SBP (mm Hg)- lying to standing (LTS)}

DISCUSSION: The present study was conducted on 59 first M.B.B.S students (29 males and 32 females) newly admitted to belonging to age group 17-22 years. In the present study, the main finding is that in healthy young subjects, a real life stressor in form of adjusting to the demands of medical training in first years, significantly impacts autonomic inputs of cardiovascular regulations after practicing pranayama.

The stress level was tested using stress questionnaire and Wilcoxon sign rank test used to test the significance. Twelve questions showed significant change in response after pranayama which show subjective improvement in perception of stress. The psychological change improves the physiology of body according emerging aspect of medicine which is known as mind - body medicine or psychoimmunoneurology.

In our study of HRV, only frequency domain parameters showed significant change because for short term HRV, frequency domain parameters reflect autonomic function. Time domain parameters are better commented on long term or 24 hours ECG acquisitions. In frequency domain parameters we observed the significant decrease in the power VLF. VLF indicates possibly renin angiotensin system. Renin angiotensin system is activated by sympathetic, decrease in BP and decreased sodium delivery to macula densa cells. The possible decrease VLF can be attributed to decrease in sympathetic stimulation. LF in n.u has decreased which indicated that sympathetic influence has decreased. HF in n.u has increased which indicated that parasympathetic influence has increased. LF/HF is also showing significant reduction of ratio indicating improvement of Sympathovagal balance i.e. decrease in sympathetic influence and increase in parasympathetic influence.

In autonomic reactivity tests also there was very significant improvement. In isometric handgrip dynamometer test the increase in diastolic B.P. is

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significantly improved indicating better reactivity. In cold pressure test also the increase in DBP is improved after pranayama. In lying to standing test, the decrease in SBP is significant indicating better autonomic control.

There is positive correlation between total score and LF in n.u. Total score and LF/HF ratio before pranayama. Also, after pranayama there is positive correlation between total score and LF in n.u and there is negative correlation between total score and HF in n.u. since most of the questions were negative, there exist positive correlation with LF power and negative correlation with HF power but the significant correlation points out that questionnaire i.e. test for stress and autonomic functions have correlation. Such correlation is also studied by Srinivasan et al [22]. According to mind body medicine and psychoimmunoneurology, we use thought process of the patient to bring about self healing [22].

Jerath et al [23] has explained the mechanism of how pranayamic breathing interacts with the nervous system affecting metabolism and autonomic functions remains to be clearly understood. It is our hypothesis that voluntary slow deep breathing functionally resets the autonomic nervous system through stretch-induced inhibitory signals and hyperpolarization currents propagated through both neural and non-neural tissue which synchronizes neural elements in the heart, lungs, limbic system and cortex. During inspiration, stretching of lung tissue produces inhibitory signals by action of slowly adapting stretch receptors (SARs) and hyperpolarization current by action of fibroblasts. Both inhibitory impulses and hyperpolarization current are known to synchronize neural elements leading to the modulation of the nervous system and decreased metabolic activity indicative of the parasympathetic state. In this paper authors proposed that pranayama's physiologic mechanism through a cellular and systems level perspective, involving both neural and non-neural elements.

It has been reported that pranayama improves cardio respiratory functions [16, 17] and alters autonomic functions. There are studies on effect of particular pranayama on autonomic nervous system like effects of nadishuddi and Kapalabhati. Pranayama breathing has been shown to alter the autonomic activity. Telles et al have demonstrated pranayama breathing through right nostril results in increase in sympathetic activity whereas left nostril breathing reduces it [18, 19]. Raghuraj et al [20] have reported that slow pranayama (nadishuddi) increase parasympathetic activity whereas fast pranayama (kapal Bhati) increase sympathetic activity. Pal et al [21] studied the effect of short term breathing exercise on autonomic function. They have studied kapalbhati and nadishuddi on Valsalva manuvre, deep breathing and lying to standing. Since Udupa et al [16, 17] has reported that fast and slow pranayama have synergistic effects, we clubbed fast and slow pranayama in the present study. The effect of combination of pranayama, described earlier was studied on various autonomic function tests. The earlier studies along the same lines were done on small number of subject whereas our study has taken larger sample size and therefore the results obtained can be used for extrapolation at large.

LIMITATIONS: We have used only a single composite questionnaire based measure of stress and have not studied psychological factors such as appraisal and coping mechanism that influence stress response. Other sources of stress such as familial, personal etc were not assessed. Biochemical parameter of stress such as plasma or salivary cortisol was not measured. In addition, our data is restricted to cardiac autonomic reactivity and did not evaluate vascular reactivity. For any confounding factor even control group having similar features but not practicing pranayama was not considered.

The scope of the present study can be expanded by further studies. This is exploratory study. A further study has to be designed taking advantage of current molecular methods and imaging technology to study various biochemical and physiological parameters. This will not only enable to fortify cause and effect relationship but also throw light on the underlying mechanism.

CONCLUSION: The present study concludes that:-

1. The stress level has reduced after 2 months of practicing various pranayama as evident by decrease in total stress score which is highly significant. Therefore pranayama improves subjective perception of an individual.
2. VLF has reduced significantly after practicing pranayama indicating possible improvement in long term sympathetic control.
3. LF in n.u has reduced significantly after practice of pranayama signifying reduction in sympathetic drive to heart.
4. HF in n.u has increased significantly after practice of pranayama for 2 months showing the increase in parasympathetic output to the heart.
5. LF/HF ratio reduced significantly after 2 months of practice of pranayama indicating a better sympathovagal balance with resting balance tilting toward better parasympathetic control.
6. There is correlation between total stress score and LF (in n.u) in pre and post pranayama which was significant.
7. There is negative correlation between total stress score and HF (in n.u) in pre and post pranayama which was significant.
8. There was correlation between LF/HF ratio and total stress score pre and post pranayama and again it was significant.

REFERENCES:

1. Ratna Sharma et al. Assessment of computer game as a psychological stressor. Ind J Physio and Pharmac. 2006; 50 (4): 367-374.
2. Maunder RG, Lancee WJ, Nolan RP, Hunter JJ, Tannenbaum DW. The relationship of attachment insecurity to subjective stress and autonomic function during standardized acute stress in healthy adults. J Psychosom Res. 2006 Mar; 60(3):283-90.
3. Rosenberg PP. Student's perception and concerns during their first year in medical school. J Med Educ 1971; 46: 211-218
4. Miller P McC. The first year at medical school: some finding and student perceptions. J Med Educ 1994; 28: 5-7
5. Vitaliano PP, Russo J, Carr JE Heerwagen JH. Medical school pressures and their relationship to anxiety. J Nerv Ment Dis 1984; 29: 119-127
6. Stewart SM, Betson C, Marshall I, Wong CM, Lee PWH. Stress and vulnerability in medical students. Med Educ 1995; 29: 119-127
7. Wolf TM. Stress, coping and health: enhancing well-being during medical school. Med Educ 1994; 28:8-17
8. Rosanki A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation 1999; 99: 2192-2217
9. Lucini D, Norbiato G, Clerici M, Pagani M. Haemodynamic and autonomic adjustments to real life stress conditions in humans. Hypertension 2002; 39: 184-188
10. Singh JP, Larson MG, Tsuji H, Evans JC, O'Donnell CJ, Levy D. Reduced heart rate variability and new-onset hypertension: insight into pathogenesis of hypertension: the Framingham heart study. Hypertension 1998; 32: 293-307
11. Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart Rate Variability Standards of measurement, physiological interpretation and clinical use. Circulation 1996; 93: 1043-65.
12. Iyengar, B. K. S. Light on Pranayama: The Yogic Art of Breathing. New York: Crossroad;1998
13. Mathias CJ and Bannister SR, Investigation of autonomic disorders. In: Bannister SR and Mathias CJ, editors, Autonomic Failure. A text book of clinical disorders of Autonomic Nervous System. 3rd ed. New York: Oxford University press: 1992, p.211-223.
14. Low PA. Laboratory Evaluation of Autonomic Function. In: Low PA, editor. Clinical Autonomic Disorders. New York: Lippincott- Raven Publisher; 1997. p.309-322.

15. Malik M. Clinical Guide to Cardiac Autonomic Tests. Netherlands: Kluwer Academic publishers; 1998, p.121-130.

16. Udupa, K. N., & Singh, R. H..The scientific basis of yoga. Journal of the American Medical Society 1972, 220, (10), 1365.

17. Udupa, K. N., Singh, R. H., & Settiwar, R. M. Studies on the effect of some yogic breathing exercises (pranayamas) in normal persons. Indian Journal of Medical Research 1975, 63, (8), 1062-1065.

18. Telles S, Nagarathna R, Nagendra HR. Physiological measures of right nostril breathing. J Altern Complement Med. 1996 Winter; 2(4):479-84.

19. Telles S, Nagarathna R, Nagendra HR. Breathing through a particular nostril can alter metabolism and autonomic activities. Indian J Physiol Pharmacol. 1994 Apr;38(2):133

20. Raghuraj P, Ramakrishnan AG, Nagendra HR, Telles S. Effect of two selected yogic breathing techniques of heart rate variability. Indian J Physiol Pharmacol. 1998 Oct; 42(4):467-72.

21. Pal GK, Velkumary S, Madanmohan. Effect of short-term practice of breathing exercises on autonomic functions in normal human volunteers.Indian J Med Res. 2004 Aug;120(2):115-21

22. Srinivasan, Mario Vaz, Sucharita. A study of stress and autonomic nervous function in first year undergraduate medical students. Ind J Physio and Pharmac. 2006; 50 (3): 257-264.

23. Jerath R, Edry JW, Barnes VA, Jerath V. Physiology of long pranayamic breathing: neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. Med Hypotheses. 2006;67(3):566-71. Epub 2006 Apr 18.