Research article

Correlation between serum cortisol levels and practice of yoga and meditation in medical students

Kavitha M.M[1], Chandrashekharayya S.H[2], Anagha V.S[3], Kashinakunti S.V[1]

[1]Department of Biochemistry, [2]Department of Otorhinolaryngology, [3]Medical student, S.Nijalingappa Medical College and Hanagal Shree Kumareshwara Hospital and Research Centre, Navanagar, Bagalkot, Karnataka, India

(Received: October 2023 Revised: November 2023 Accepted: December 2023)

Corresponding author: **Kavitha M. M.** Email: mekch@rediffmail.com

ABSTRACT

Introduction and Aim: Recent year's yoga has gained a very good response in today's world as one of the natural methods to reduce stress. Yoga acts as an adjuvant to many kinds of treatment for various stress-related disorders. To meet the modern lifestyle full of tension, stress and challenges and to gain all round personality development yoga is mandatory. With this background current study was carried out, to estimate and compare the serum cortisol levels and heart rate variability and also to evaluate the relationship between serum cortisol levels, heart rate variability before and after yoga and meditation practice for six weeks in study group and control group in first year medical students.

Material and Methods: Informed consent was obtained before the start of the study. The current study was a quasi-experimental study with 80 subjects, 40 medical students as cases which is an interventional group and 40 students as a control group. For a period of six weeks, yoga and meditation practice was given to an interventional group by a yoga master daily for one hour.

Results: After practicing yoga regularly and promptly, cases showed decrease in serum cortisol levels and improvement in HRV parameters, frequency domain values like RMSSD increased and among time domain values HF increased and LF, LF/HF ratio decreased. There was no change observed in serum cortisol levels and HRV parameters of the control group. We observed statistically significant negative correlation between serum cortisol levels and HRV parameters in the interventional group after yoga practice.

Conclusion: Hence, incorporation of yoga and meditation as part of our lifestyle in medical students will help them to cope up with day-to-day stress during their study period.

Keywords: Serum cortisol; yoga; heart rate variability; meditation.

INTRODUCTION

Hans Selye in 1926 introduced the concept of stress as the organism's response to environmental stimuli(1). Stress can be the non-specific response of the body to each request which is known as "Selyan sense". The hypothalamo-pituitary-adrenal axis is a neuroendocrine system, which sets up stress reactions, and it also controls the emotions, mood, immune system and metabolism (2,3). In 1984 by Richard Lazarus, stress is a two-way process which involves the production of stressors by the environmental stimuli and individual response to these stressors (4-6).

Adrenal cortex produces cortisol in the zona fasciculata. Its secretion is controlled mainly by adrenocorticotropin (ACTH) released from the anterior pituitary which is regulated by corticotrophin-releasing hormone (CRH). Stress acts directly on the hypothalamus to stimulate CRH release while cortisol exerts negative feedback on both ACTH and CRH secretion. Cortisol secretion follows a circadian rhythm.

Cortisol is proposed as the biological maker of stress. The hypothalamus-pituitary-adrenal axis gets stimulated by exposure to stress, to increase the secretion of stress-related glucocorticoid hormones, like cortisol (7,8) which is responsible for many detrimental health issues brought by stress response (9-11).

Heart Rate (HR) in humans is influenced by physical, emotional, and cognitive activities, and is an index of beat-to-beat changes in the heart rate known as heart rate variability (HRV; 12-14). HR and HRV are the most sensitive non-invasive indicators of autonomic regulation and vagal activity. HRV represents the relative signals of autonomic nerve activity in the body i.e., root mean square of successive difference (RMSSD) between normal heart beat which is recorded for 5 minutes, representing beat to beat variation. Low frequency (LF), which is recorded for 2 minutes, represents the sympathetic activity of nerves. High frequency (HF) represents the parasympathetic activity which is recorded for 1 minute. The ratio of LF and HF is a "sympatho-vagal balance" which means the status of balance between parasympathetic and sympathetic nervous systems (15.

Yoga is a body–mind exercise. It has a beneficial effect on mental health like concentration, attention, anxiety, stress, mood, resilience, emotional arousal,

self-esteem and coping frequency (16,17). Knobben in his literature search study concluded that the effects of practicing yoga on quality of life and improvement in mental wellbeing in healthy individuals and in patients (18).

The aim of the present study was to check the effect of yoga and meditation practice on stress and heart rate variability in medical students. We conducted a Quasi-experimental study of yoga and meditation for medical students. The present study was conducted, to estimate and compare the serum cortisol levels and heart rate variability before and after yoga and meditation practice for six weeks in study group and control group in first year medical students. Also to evaluate the relationship between serum cortisol levels, heart rate variability before and after practice of yoga.

MATERIALS AND METHODS

This was an interventional case-control study conducted in the Biochemistry department. The study was conducted at S. Nijalingappa Medical College and Hanagal Shri Kumareshwar Hospital and Research Centre, a tertiary care centre, Bagalkot, Karnataka, India. Approval was taken prior to the study by the Institutional Ethics Committee (IEC) with reference number SNMC/IECHSR/2021-22/10.1. Informed written consent was taken from all the medical students who are enrolled at the beginning of the study. The study was conducted over a period of three months from August to October 2021. Healthy volunteers willing to practice yoga were included in the study. Individuals suffering from endocrine diseases, psychiatric disease were excluded from the study.

Sample size was calculated using open epi software version 2.3.1 by taking the previous reference according to Kumar *et al.,* (19). Proportion of participants with decreasing trends of cortisol in yoga groups is 60%. Proportion of participants with decreasing trends of cortisol in the control group is 28%. At 95% confidence interval and 80% power of the study sample size estimated was 38 and rounded off to 40 in each group.

Study comprises of total 80 participants, who were the 1styear medical students. There were 40 in the intervention group, one who practiced yoga for six weeks and 40 in the control group who does not practice yoga. All 80 medical students were explained the study protocol and were counseled and motivated to take part in the study. Informed written consent was taken from all the medical students. Detailed history of diet, habits, exercise, family history, and socioeconomic status, academic performances were taken. General physical examination like height, weight, body mass index (BMI), pulse rate (PR), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), partial pressure of oxygen ((SpO_2) was recorded and noted. Serum cortisol was estimated and Heart rate variability (HRV) parameters like RMSSD, HF, LF and LF/HF ratio were recorded in the yoga practice group and control group at the beginning of the study. Heart rate variability (HRV) was recorded in all the students using the Power lab-AD instrument. HRV analysis was done using software version8.

Yoga practice participants (cases) were asked to practice yoga and meditation for one hour every day for six weeks. Yoga was practiced every day in the evening between 5.30 to 6.30 pm under supervision by a yoga teacher. It included warm up exercise in the first fifteen minutes, practice of asanas in next fifteen minutes, pranayama in next fifteen minutes and followed by meditation for the last fifteen minutes shown in Table 1,whereas control group was not practicing any yoga and meditation. After six weeks of interval serum cortisol and heart rate variability was recorded in both yoga practice group i.e., cases and control group.

Table 1: Distribution of time and list of asanas performed during practice of yoga and meditation

Total duration	Yoga titles	Subtitles
First 15 Mins	Warm up exercise	Jogging; Stretching; Twisting; Bending; *Surya namaskar*
Next 15 Mins	*Asanas*	*Tadasana; Padahastasana;Ushtrasana; Vrikshasana;Trikonasana; Parivruttatrikonasana;Vajrasana; Shashankasana;Padmasana Baddha padmasana;Gomukhasana;Ardhamathsandreyasana Paschimottanasana;Parvatasana; Virabhadrasana Makarasana;Sholabhasana;Bhujangasana;Dhanurasana;Navasana*
Next 15 Mins	*Pranayama*	*Kapalbhati; Bhastrika;Anuloma-viloma;Sheetali-sheetkari Brhamari*
Last 15 Mins	Meditation	Audio with Om was chanted

Under aseptic precaution, early in the morning at 8 AM, around 3 mL of fasting venous blood was drawn from the ante-cubital vein. After centrifugation, the serum was separated, and cortisol was estimated immediately. The serum cortisol was estimated by the chemiluminescence immunoassay method using MAGLUMI SNIBE 1000, fully automated analyzer. Analysis was done in software (SPSS version 21). Student 't' test was used to compare the serum cortisol levels between yoga group and control group. Pearson's correlation was used to correlate.

RESULTS

The present study comprises 80 first year medical students, out of which 40 cases (Interventional group) and 40 were controls, of age group between 18 to 20 years, first year medical students. The mean age of cases and control was 18.01±0.5 years. In cases there were 21 male and 19 female participants. In the control group 20 male and 20 were female participants.

General physical examination like height, weight, BMI, PR, RR, SBP, DBP and SPO_2 recorded in control and intervention group (cases) before practice of yoga shown in Table 2. There was no significant difference in these parameters. Serum cortisol levels in controls before practice of yoga was 18.36±4.8 µg/dL and in cases 18.98±4.7 µg/dL. HRV parameters like RMSSD, HF, LF and HF/LF ratio were recorded shown in Table 3 and there was no statistical difference found in these parameters.

Anthropometric parameters like height, weight, BMI, PR, RR, SBP, DBP and SPO_2 recorded in control group and intervention group (cases) after practice of yoga shown in Table 4. There was no significant difference in these parameters.

Table 2: Comparison of anthropometric parameters between control and cases before practice of yoga

Parameters	Controls	Cases	t	p-value
Height cm	164.42±6.7	167.17±9.9	1.4	0.14
Weight kg	62.34±12.15	62.1±15.29	0.1	0.91
BMI kg/m²	23.11±4.42	22.2±4.5	0.92	0.35
PR /m	88.62±11.2	89.35±12.47	0.27	0.78
RR/m	17.87±2.7	17.6±2.5	0.47	0.63
SBP mmHg	118.95±11.04	118.4±12.24	0.19	0.84
DBPmmHg	74.88±7.4	74.64±8.5	0.13	0.89
SPO_2%	98.07±0.8	98.00±0.9	0.37	0.71

Table 3: Comparison of serum cortisol levels and HRV parameters between control and cases before practice of yoga

Parameters	Controls	Cases	t	p-value
Cortisol µg/dL	18.36±4.8	18.98±4.7	0.19	0.84
RMSSD ms	47.01±20.02	46.02±20.53	0.22	0.82
LF nu	39.57±14.64	37.7±16.22	0.54	0.58
HF nu	57.30±12.56	56.95±12.42	0.12	0.89
LF/HF	0.77±0.61	0.77±0.6	-	-

Table 4: Comparison of anthropometric parameters between control and cases after practice of yoga

Parameters	Controls	Cases	t	p-value
Height cm	164.42±6.7	167.17±9.9	1.46	0.14
Weight kg	62.34±12.15	61.53±14.5	0.27	0.78
BMI kg/m²	23.11±4.42	22.2±4.5	0.92	0.35
Pulse /m	90.62±11.2	87.6±12.69	0.38	0.70
RR/m	18.87±2.7	16.15±2.86	2.79	0.006
SBP mmHg	118.4±10.5	118.4±12.24	0	0
DBP mmHg	76.32±6.63	74.64±8.5	0.99	0.32
SPO_2%	98.07±0.8	98±0.9	0.37	0.71

Table 5: Comparison of serum cortisol levels and HRV parameters between control and cases after practice of yoga

Parameters	Controls	Cases	t	p-value
Cortisol µg/dL	19.63±4.9	16.21±4.2	3.39	0.001
RMSSD ms	47.01±20.02	58.23±20.1	2.53	0.01
LF nu	39.57±14.64	28.56±14.16	3.46	0.001
HF nu	57.30±12.56	68.8±12.29	4.19	0.001
LF/HF	0.77±0.61	0.42±0.60	2.61	0.01

RMSSD: Root mean square of successive difference between normal heart beat, LF: Low frequency, HF: High frequency

Mean serum cortisol levels in controls after practice of yoga was 19.63±4.9 µg/dL and in cases 16.21±4.2 µg/dL. There was significant reduction in serum cortisol levels in cases i.e., intervention group compared to controls after regular yoga practice and meditation every day. Even in HRV parameters like

RMSSD and HF were significantly increased and LF and LF/HF ratio decreased, which are statistically significant shown in Table 5.

Mean serum cortisol was 18.98±4.7 µg/dL before practice of yoga and reduced to 16.21±4.2 µg/dL after practice of yoga in cases (Fig.1). We observed significant decrease (p<0.005) in serum cortisol levels in cases after regular practice of yoga and meditation shown in Fig.1. HRV, RMSSD and HF increased and LF and LF/HF ratio significantly decreased shown in Fig 2.

There were no changes in HRV parameters before and after, at an interval of one month gap in the control group. We can see a slight increase in serum cortisol levels 19.63±4.9 µg/dL in cases after one month compared to before 18.36±4.8 µg/dL which was not statistically significant (p=0.67).

In the present study Pearson's correlation between serum cortisol and RMSSD showed negative correlation with r value 0.6 after practice of yoga in cases

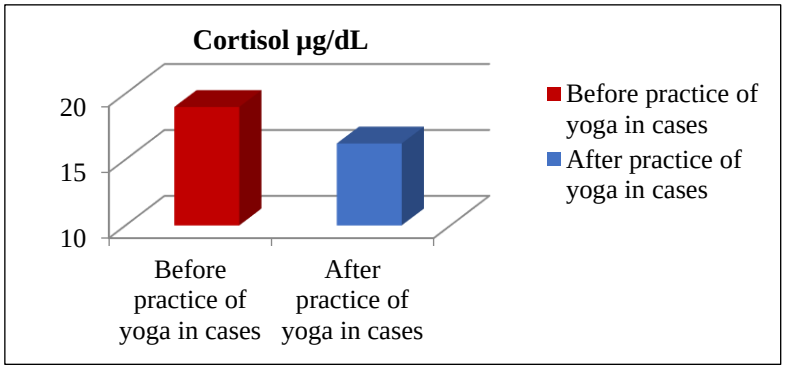

Fig.1: Mean serum cortisol levels in cases before and after practice of yoga and meditation

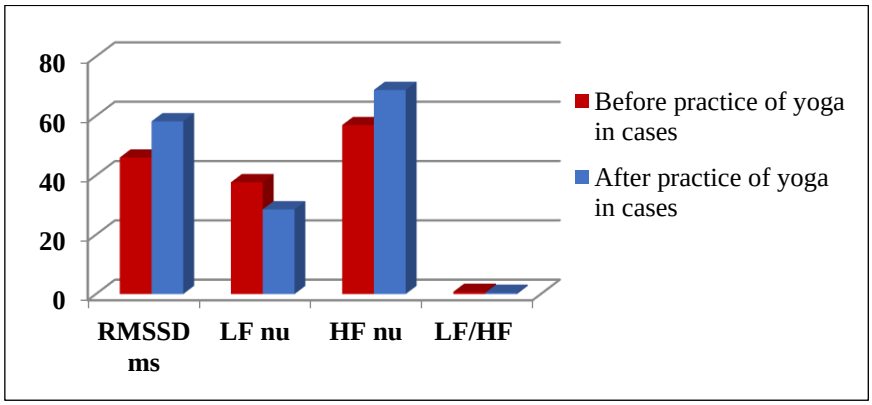

Fig.2: HRV parameters in cases before and after practice of yoga and meditation

DISCUSSION

The present study was planned to correlate between serum cortisol levels and practice of yoga and meditation in medical students. Yoga influences pulse rate, respiratory rate, SBP, DBP, SPO_2,cortisol levels and heart rate variability parameters i.e., RMSSD, LF, HF and LF/HF ratio. The main findings of our study were that practice of yoga and meditation decreases serum cortisol levels in first year medical students. Yoga reduces sympathetic nervous control, increases parasympathetic nervous control and therefore reduces heart rate and respiratory rate, oxygen consumption and stress. This supports the practice of yoga and meditation plays a significant role in maintaining a healthy mind in a healthy body (20).

Quite a few studies have been conducted and have shown significant reduction in cortisol levels. Research conducted by Mandal *et al.*, showed significant decrease (p<.05) in mean serum cortisol values 13.72±5.72 to 9.45±3.81 µg/dL of the study group after 3 months of yoga practice when compared with control group 12.08±4.96 µg/dL at end of 3 months of practice of yoga (16).

Our study even signifies improvement in HRV parameters. After practice of yoga and meditation for a period of 4 weeks RMSSD and HF values increased and LF and LF-HF ratio decreased. In a study conducted by Kuppuswamy *et al.*, reported practicing yoga continuously for 6 months the short term HRV showed significant ($p < 0.05$) improvement in parasympathetic system (21).

Numerous attempts have been made to correlate between serum cortisol levels and yoga and meditation; heart rate variability and practice of yoga

and meditation. Significant correlation has been found between serum cortisol levels, heart rate variability and practice of yoga and meditation in this study. Various central, autonomic, mechanical and haemodynamic adjustments which lead to tonic and phasic changes in cardiovascular functioning are triggered through modified breathing patterns which mediate autonomic modulation in yoga (22). This modulation is brought through the conditioning effect of yoga and mediated through higher areas of CNS and limbic system (23). Increased baroreflex sensitivity and decreased sympathetic tone is achieved by regular practice of yoga.

Stress induced sympathetic over activity is reduced by meditation by modifying the state of anxiety. In a society filled with tension, practice of yoga and meditation will bring solutions to all problems and enhance the essence of life. The practice of asanas influences haemodynamic mechanism and neuro-endocrine axis, thereby restoring equilibrium by avoiding intervention of the inhibitory parasympathetic system (24). Increased parasympathetic activity decreased firing of paragiganto cellular nucleus of medulla which reduces stimulation of locus coeruleus. By this norepinephrine release is reduced causing quiescence and relaxation (25). Different postures of yoga increase GABA activity, thus leading to less depression and anxiety states (26).

Yoga practice stimulates vagus nerve and parasympathetic output (27) causing enhanced neuroendocrine, immune, cardiac and metabolic responses. Flexible and adaptive interaction between prefrontal cortex, amygdala and peripheral organs is allowed by bidirectional flow of vagus which mediates emotional and behavioural response. HRV reflects cognitive influence on organ function and mind-body integration by various yoga practices. Many studies show the practice of yoga to reduce autonomic arousal and increase parasympathetic tone and assist a wide range of stress related disorders (28).

CONCLUSION

The present study concludes significantly decreased serum cortisol levels and increased RMSSD, HF and decreased LF and LF/HF ratio in heart rate variability parameters in yoga practice group and meditation when compared to control group. Further, a positive correlation of statistical significance was found between serum cortisol, heart rate variability and practice of yoga and meditation in yoga group in first year medical students.

ACKNOWLEDGEMENT

We thank all the medical students who enrolled in this study. This was an ICMR sponsored research work.

CONFLICT OF INTEREST

The authors have no conflicts of interest.

REFERENCES

1. Selye, H. The stress of life. New York, McGraw-Hill, 1956.http://psycnet.apa.org
2. Sydor, A., Brown, R.Y. Molecular neuropharmacology: A foundation for clinical neuroscience. McGraw-Hill Medical, 2008.
3. Fraser, R., Ingram, M.C., Anderson, N.H., Morrison, C., Davies, E., Connell, J.M. Cortisol effects on body mass, blood pressure, and cholesterol in the general population. Hypertension. 1999; 33:1364-1368.
4. Patra, S., Telles, S. Heart rate variability during sleep following the practice of cyclic meditation and supine rest. Appl Psychophysiol Biofeedback. 2010;35:135-140.
5. Lazarus, R.S. From Psychological stress to emotions: A history of changing outlooks. Annual Review of Psychology. 1993;44:1-22.
6. Vinay, A.V., Venkatesh, D., Ambarish, V. Impact of short-term practice of yoga on heart rate variability.2016;9(1):62-66.
7. Kareri, D., Manafe, D.T., Sasputra, I.N. Exercise habits and cortisol level among women at a local Zumba club. Biomedicine. 2022 Sep 12;42(4):820-822.
8. Sujina, S.S., Chandran, V., Manjrekar, P., Marathe, A., Pawar, N. Correlation of hepatic transaminases with cortisol levels in type 2 diabetes. Biomedicine. 2023 Aug 30;43(4):1143-1147.
9. Vogelzangs, N., Beekman, A.T., Milaneschi, Y., Bandinelli, S., Ferrucci, L., Penninx, B.W. Urinary cortisol and six-year risk of all-cause and cardiovascular mortality. J Clin Endocrinol Metab 2010;95:4959-4964.
10. Rosmond, R., Dallman, M.F., Björntorp, P. Stress-related cortisol secretion in relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. J Clin Endocrinol Metabolism. 1998;83:1853-1859.
11. Garcez, A., Weiderpass, E., Canuto, R., Lecke, S.B., Spritzer, P.M., Pattussi, M.P., *et al.,* Salivary cortisol, perceived stress, and metabolic syndrome: A matched case-control study in female shift workers. Horm Metab Res. 2017;49:510-519.
12. Balamadhuwanthi, S., Latha, R., Vedapriya, D.R., Tamilselvan, K., Mathangi, D.C. Effect of chair yoga on heart rate variability, perceived stress, and sleep quality among nursing professionals from a tertiary care hospital. Biomedicine. 2023 Apr 9;43(01):499-503.
13. Galag, S.C., Rajalakshmi, R., Desai, N., Basavanagowdappa, H. The effect of deep breathing test on heart rate variability in obese and non-obese patients with myocardial infarction. Biomedicine. 2021 Apr 3;41(1):93-98.
14. Thayer, J.F., Hansen, A.L., Saus-Rose, E., Johnsen, B.H. Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation and health. Ann Behav Med. 2009;37:141-153.
15. Uppal, M.K., Xiong, G.L., Doraiswamy, P.M. Does meditation enhance cognition and brain plasticity? Ann NY Acad Sci. 2009;72(11):63-69.
16. Mandal, I., Sharma, M.,Gupta, I.D., Chauhan, N. An interventional study showing effect of yoga on serum cortisol of depression patients attending psychiatric OPD, SMS Hospital, Jaipur.2016;4(3E):971-972.
17. Latha, R., Lakshmi, S.S. A study on immediate and training effect of Bhramari pranayama on heart rate variability in healthy adolescents. Biomedicine. 2022 Sep 12;42(4):784-788.
18. Knobben, S. A meta-analysis of the effectiveness of yoga on mental health; taking on a dual perspective reflecting the medical and positive perspective of mental health. Doctoral thesis, University of Twente, the Netherlands. 2013.
19. Kumar, K., Singh, V., Kumar, D., Asthana, A.B., Mishra, D. Effect of yoga and meditation on serum cortisol level in first-year medical students. Int J Res Med Sci. 2018;6(5):1699-1703.

20. Dhawan, A., Chopra, A., Jain, R., Yadav, D. Vedamurthachar effectiveness of yogic breathing intervention on quality of life of opioid dependent users. Int J Yoga. 2015;8(2):144-147.
21. Kuppuswamy, M., Kamaldeen,D., Pitani, R., Amaldas, J., Ramaswamy, P., Shanmugam, P., *et al.*, Effects of yoga breathing practice on heart rate variability in healthy adolescents: A randomized controlled trial. 2020;9(1):28-32.
22. Herur, A., Kolagi S., Surekharani, C. Effect of yoga on cardiovascular and mental status in normal subjects above 30 years of age. Al Ameen J Med Sci. 2010;3(4):337-344.
23. Selvamurthy, W., Nayar, H.S., Joseph, N.T., Joseph, S. Physiological effects of yogic practice. NIMHANS Journal. 1983;71-80.
24. Vatve, M., Sahoo, K.D., Patil, V.V. Effect of specific 'yogasanas' on cardiovascular autonomic function test. Pravara Med Rev. 2010;5(1):1-9.
25. Thirthalli, J., Naveen, G.H., Rao, M.G., Varambally, S., Christopher, R., Gangadhar, B.N. Cortisol and antidepressant effects of yoga. Indian Journal of Psychiatry.2013;55:405-408.
26. Streeter, C.C., Gerbarg, P.L., Saper R.B, Ciraulo, D.A., Brown, R.P. Effects of yoga on the autonomic nervous system, gamma aminobutyric-acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. Medical Hypotheses. 2012;78(5):571-579.
27. Innes, K.E., Bourguignon, C., Taylor, A.G. Risk indices associated with the insulin resistance syndrome, cardiovascular disease, and possible protection with yoga: A systematic review. J Am Board Fam Pract. 2005;18:491-519.
28. Khalsa, S.B. Yoga as a therapeutic intervention: A bibliometric analysis of published research studies. Indian J Physiol Pharmacol. 2004;48:269-285.