Assessment Of Examination Stress And HRV in Adolescents

Dr Dhan Raj Bagri*, Dr Ashok Gupta, Dr Amitabh Dube***, Dr R K Gupta******

*Js Paediatrics,Govt Of Rajasthan ,Ex Senior Registrar ,SPMCHI, J K Lon SMS Medical College, Jaipur.** Senior Professior, Unit Head And Suprintendent, SPMCHI,J K Lon , SMS Medical College, Jaipur.*** Professior &Hod Physiology, SMS Medical College Jaipur.****Professior And Unit Head , SPMCHI JK Lon , SMS Medical College Jaipur.

Abstract: Objective.The present study was designed to define and evaluate examination stress among ,adolescents in the age group of 12–18 years in relation to heart rate variability (HRV), an index of sympathovagal interplay, one of the sensitive neurophysiological axes to be influenced initially, when an individual is exposed to any stressor.Methods. Hari's stress inventory for students was used to qualify examination stress was collected on 69 healthy school students, free from any acute or chronic ailment, one month and seven days before the start of final examinations along with acquisition of short – term HRV to profile the sympathovagal interplay, a sensitive index of both physical and mental stress. Results. The stress inventory depicted that the sample population was under an enhanced mental stress 7 days before the examination as compared to that observed 1 month before the ratios of HRV 1month and 7 days before the final examination. Significant appreciable difference could also be appreciated in the values of SDANN in time domain and amplitude of the waveforms in HF, LF on the frequency domain of HRV.Conclusion. An enhanced sympathetic outflow as discerned through increase in LF/HF ratio and LF power with a concomitant decrease in HF power along with significant decrease in SDANN values profiling a decreased vagal outflow of the student population denotes an autonomic neurophysiological status that needs a specialist attention in terms of proper and adequate guidance and counselling**.** [Bagri D NJIRM 2016; 7(4):1-7]

Key Words: Examination Stress ,HRV,Student Suicide

Author For Correspondence: Dr Dhan Raj Bagri, Pediatrics, Govt Of Rajasthan ,Ex Senior Registrar, SPMCHI,J K Lon SMS Medical College Jaipur. Email: meena.drdhanraj6@gmail.com M: 91 9413332633

Introduction: The adolescent population in India in general, and the students living in metropolitan areas in particular, has shown alarming increase in manifestations of stress, suicide and anxiety related disorders in recent times[1]. A large amount of this stress seems to be examination related, with sharp peaks in psychological emergencies around the time of competitive examinations. Appearing for examination is one of very common situation which is considered stressful by the adolescents. Studies show that three factors seem to contribute maximally to stress about examinations – tension or the motor response to the event, social derogation, which is the fear of what people will think, and finally, cognitive blocking or obstruction [2.]Tension often expresses itself in the form of tensions headaches, writer's cramps, and similar complaints that are rushed to the pediatrician as emergencies, just prior to examinations. Adolescents are more likely to be over – stressful at and during the examinations because of labile and nimble emotionality. The examination of Class X and XII standard fall during this period of adolescence. These examinations are considered more important with the view of pursuing the career, bringing an undue level of anxiety in parents which is then translated onto their adolescent progeny (ies). Examination calls in for some tensions, anxiety and stress [3].

"Heart Rate Variability (HRV) is a measure of the continuous interplay between sympathetic and parasympathetic influences on heart rate that yields information about autonomic (ANS) flexibility and thereby represents the capacity for regulated emotional responding. It can be explained as the variation in the beat to beat time interval that show accelerating and decelerating oscillations. Measurements are using R – R intervals from a single lead ECG that are then processed digitally into identifiable neurophysiologic components of sympathetic and parasympathetic outflow of the autonomic nervous system (ANS)[4] . A decrease in HRV means the beat to beat time interval is more and is quantifiable as increased indices of time and frequency domains of HRV that identify the sympathetic component of ANS. It has been observed that more even the frequency changes, the lower the Heart Rate Variability would be; conversely the more uneven the frequency changes, the greater the HRV. HRV is easily determined mathematically by measuring the time between successive beat R – R intervals of QRS complexes as recorded on an electro cardio graphic strip. It reflects change in beat to beat interval and such variability in the 0.12 – 0.40 seconds range is thought to be primarily under vagal control [5,6].

Porges in 1995 stated that depressed vagal activity, as assessed by changes (decrease) in heart rate variability (HRV), is a predictor of sudden cardiac

death and myocardial infarction. The depressed HRV, often related to the permanent elevation of heart rate, is among the best predictors of further cardiac events after myocardial infarction, and has been used as an index of wear and tear of a lifelong exposure to taxing and stressful situations[7]A plausible correlation exists between examination stress and heart rate variability. Today, when competition has reached a worrisome level and the developing youth is under extreme pressure to perform to fulfill parental expectations, the present study was designed to define and evaluate examination stress among adolescents in the age group of 12 – 18 years in relation to heart rate variability (HRV) an index of sympathovagal interplay, one of the sensitive neurophysiologic axes to be influenced initially when an individual is exposed to any form of stressor. [8].

AIMS AND OBJECTIVES:

1. To establish association, if any, between the examination stress and heart rate variability of the sample population under study.
2. To define the status of examination stress in adolescent population under evaluation.

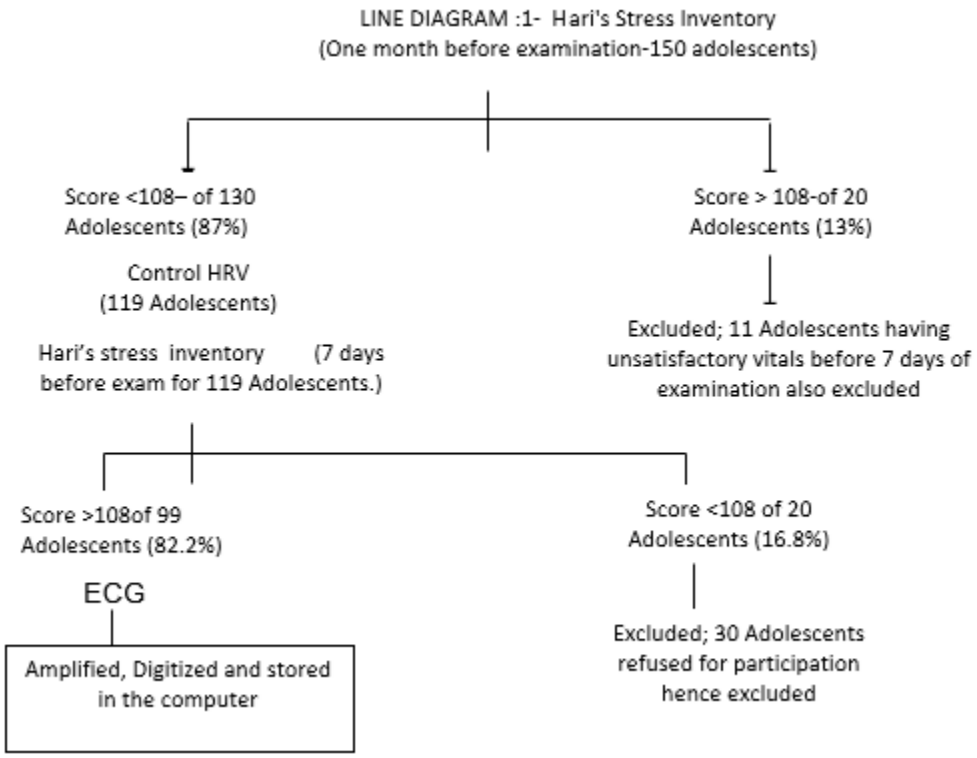
Material and Methods: The present study was conducted by Department of Pediatrics, S.M.S. Medical College and Attached Hospitals, Jaipur in association with Department of Physiology, S.M.S. Medical College,Jaipur at KV Central Senior Secondary School, Jaipur after getting the requisite clearance from the Institute Research Review Board. Informed written consent was obtained from parents and students who willingly participated in the study. School going adolescents in the age range of 12 to 18 years (of Class IX, X, XI, XII) in rested basal state were included in the present study. However, students with any acute or chronic illness or on fast were excluded from the study. The study was conducted during one month and seven days before the final examination. Stress is defined operationally by a self – report questionnaire and changes in heart rate variability, rather than by measures of general alertness or arousal. Hari's stress inventory for students, a tool that measures the amount of stress experienced in daily life, was used to measure stress due to examination (consent for using the inventory in this study was taken from Dr. Hari S. Chandran via email). This is a questionnaire of 54 questions to measure stress in different life situations. A score of more than 108 on the sliding scale is considered as psychologically stressful situation and a score of more than 168 warrants professional help to bring the levels to below 108[9].

Initially 150 students were recruited, considering the margin of permissible error and the desired level of confidence, for the study on the basis of random sampling technique, though only 69 students could participate in the study after giving their informed written consent(figure below). The 69 students with stress inventory score of less than 108 one month before but more than 108 seven days before the final examination were included in the present study. The HRV of selected 69 students was done and the HRV one month before the final examination taken as the control HRV.

Hari's stress inventory was applied on 150 adolescents 1 month and 7 days before secondary and senior secondary board examination. 20 of them were having scores >108 even before 1 month of examination and were given counseling and excluded from study ;11 Adolescents having non satisfactory vital examination during physical examination were also excluded from the study. 30 Adolescents refused to give time for HRV study before 7 days of examination. 20 Adolescents were having normal Hari's Stress Inventory scores even 7 days before examination; hence were not included in the analysis.

Rest 69 students who were having stress inventory score <115 before 1 m but >115 before 7 days were considered for analysis purpose. The HRV of selected 69 students were done and there HRV before 1 month was considered control HRV.

Percentage scores of Hari's Stress Inventory-The following line diagram(1) suggests that the incidence of stress among adolescents in general is 13%; this is in consonance with the view of experts worried about teen stress, that a significant number of adolescents are having stress these days. It may be because during this period adolescents are going through a lot of physical, emotional and social stress. 16.8% adolescents didn't have stress even before 7 days of examination. It can be concluded that some adolescents have stable sets of internal standards for their actions; but a significant percentage (82.2%) of students developed stress before 7 days of examination.



The HRV recordings were done as per the international protocol[10]. No noise or ectopic beats were found on offline scrutiny of the ECG. RR interval time-series was computed from the ECG and subjected to short – term HRV analysis using a software (HRV Software version 1.1, Autonomic Function Laboratory, Department of Physiology, All India Institute of Medical Sciences, New Delhi), as per the recommendations of the Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology in 199620 Mean of all the RR intervals (mean RR), standard deviation of the normal – to – normal RR intervals (SDNN), root mean square of successive differences between adjacent RR intervals (RMSSD) and the percentage of number of RR intervals with differences >50 ms (pNN50) were calculated in the time – domain.

Frequency-domain measures were obtained by fast Fourier transformation and they included the absolute powers obtained by integrating the powers in the very low frequency (VLF) band of 0.0033 – 0.04 Hz, low frequency (LF) band of 0.04 – 0.15 Hz, high frequency (HF) band of 0.15 – 0.4 Hz, and the total power in all the 3 bands together. The normalized units (nu) of LF and HF power, as well as the LF/HF ratio, were considered. The results, expressed as mean (SD), were analyzed using the SPSS version 11.0 statistical software package and the Gaussian distribution of data was determined. Normally distributed data (mean RR, SDNN, LF nu, HF nu, respiratory rate and MAP) were tested with the paired t – test. Non – normally distributed data (pNN50, RMSSD, LF/HF ratio, VLF power, LF power, HF power and total power) were tested with the Wilcoxon signed rank test. A value of $p < 0.05$ was considered as significant.

Results and Discussion: The present study profiled the levels and its correlation between mental stress and heart rate variability of the adolescent population under study 1 month and seven days before the start of the final examinations, with results so observed 1 month before the final examination been taken as control standard for the adolescent population. .The stress inventory in the present study depicted an increase in mental stress seven days before the final examination (with a score of 166) as compared to that observed at one month before the final examination (a score of 105). The incidence of stress among adolescents in general is 13 % that could be due to the fact that during these period adolescents go through a lot of physical, emotional and social stress, though 16.8% adolescents didn't have stress even before 7 days of examination. It could be concluded that some adolescents have stable sets of mental space and are able to cope up with stressors, both internal and external. A significant percentage (82.2%) of students

developed stress before 7 days of examination. The following line diagram(1) suggests that the incidence of stress among adolescents in general is 13%; this is in consonance with the view of experts worried about teen stress, that a significant number of adolescents are having stress these days. It may be because during this period adolescents are going through a lot of physical, emotional and social stress. 16.8% adolescents didn't have stress even before 7 days of examination. It can be concluded that some adolescents have stable sets of internal standards for their actions. But a significant percentage (82.2%) of students develops stress before 7 days of examination.

On comparative evaluation of Examination Stress and Heart Rate Variability significant difference was observed in Low Frequency/High Frequency (LF/HF) ratios of HRV 1 month and 7 days before the final examinations. Significant appreciable difference could also be appreciated in the values of standard deviation of averages normal sinus to normal sinus intervals (SDANN) in time domain and amplitude of the waveforms in HF, LF on the frequency domain of HRV, though significant difference couldn't be demonstrated in other variables of time and frequency domains of HRV. Significant changes in the amplitude of waveforms of HF and LF region could also be appreciated in the present study that could serve as a sensitive and a coherent indicator of sympathovagal interplay.

On comparing the time domain variables of HRV 1 month and seven days before the final examinations, it was observed that the average values for Central Autonomic outflow of NN50 – 95.04, PNN50 – 26.86, RMSSD – 91.04 and SDANN – 28.51 one month before examination were significantly reduced to NN50 – 85.66, PNN50 – 25.01, RMSSD – 69.63 and SDANN – 21.05 at seven days before the examination, that supplants the belief that the vagal rhythm of RSA (Respiratory Sinus Arrhythmia) [11]. is converted into sympathetic rhythm during stress in order to prepare and condition the individual for the imminent needs.

The frequency domain (Power Spectral Density – PSD) analysis describes the periodic oscillations of the heart rate signal decomposed at different frequencies and amplitudes and provides information on the amount of their relative intensity (termed variance or power) on heart's sinus rhythm. Schematically, spectral analysis may be compared to the results obtained when white light passes through a prism, resulting in different lights of different color and wave length. [12].

Table: 1 Comparison of HRV – One Month and Seven Days Before the Examination (Frequency Domain)

	VLF(% Power)	LF(% Power)	HF(% Power)	Total Power (%Power)	LF (Normalized Power)	HF (Normalized Power)
Before One Month	33.30	32.93	33.76	100	51.68	48.31
Before Seven Days	34.91	28.97	36.62	99.80	48.62	50.20

Table: 1 Continued Comparison of HRV – One Month and Seven Days Before Examination (Frequency Domain)

	LF/HF Ratio	VLF/LF Ratio	VLF (Absolute Power)	LF (Absolute Power)	HF (Absolute Power)	Total Power (Absolute Power)
Before One Month	1.91	1.26	6799.93	10127.70	3990.14	20917.78
Before Seven Days	1.73	4.74	1677.53	1608.50	3688.72	7070.31

Table 1 depicts the sympathovagal interplay (LF/HF) and the thermoregulatory central influences in relation to the sympathetic drive (VLF/LF). The average values for sympathovagal interplay 1 month before examination so recorded were 1.91 which indicates a high sympathetic drive, as is expected in adolescent individuals in their formative age range. Table 1 depicts the trend and relationship observed in various dimensions with examination stress in relation to the sympathovagal interplay at the central level. HRV seven days before the examination depicts a low LF / HF ratio (1.73) while the ratio one month before the examination was high (1.92), an interesting observation that validates the state of the autonomics in the determination and possible evolution of the neural circuitry sub serving various stress [13]. The composite non – linear nature of the LF component (a synthesis of both sympathetic and the parasympathetic) and the pure vagal influence of HF

could contribute to the present observations. Moreover, as the adolescent population under evaluation was getting prepared for the forthcoming final examinations, a plausible reason for downsizing of the LF/HF ratio seven days before the examination could be the neurophysiologic resilience and capability of the individuals to handle the stressor physiologically, even though the psychological score of stress was increased during this timeline. However, it was observed that the peak amplitude in LF zones was significantly decreased 7 days before the examination as compared to that observed one month before the examination. It was also observed during the study of waveforms that the peak amplitude of waveforms in LF and HF zones elaborated significant increase seven days before the examination (see table 3).

Table 2 gives the non – linear analysis of HRV in the sympathetic (SD2) and parasympathetic (SD1) domain. As depicted in the table the sympathetic is SD2 and parasympathetic is that of HRV triangular index and TINN and SD1 respectively.

Table: 2 Comparison of HRV 1 month and 7 days Before the Examination (Non – Linear)

	SD1	SD2	SD1/SD2	HRV Triangular Index	TINN
Before One Month	64.02	113.65	0.49	0.19	491.03
Before Seven 5oDays	49.29	88.68	0.46	0.18	352.01

The high value of TINN one month before examination suggests optimal variability of TINN one month before examination which decreased seven days before examination.

Table: 3 The LF and HF Amplitudes of HRV One Month and Seven Days Before Examination (Frequency Domain)

Parameter	1 month before examination		7 days before examination		t-value
	Average	Std deviation	Average	Std deviation	
LF Amplitude	33.0	14.98	49.6	15.82	4.099
HF Amplitude	42.13	21.54	29.73	11.31	-2.742
LF/HF Amplifier	1.08	0.85	1.82	0.669	3.681

at the t-values so depicted $p < 0.05$ and is Significant

Table 4: Hari's Stress Inventory Scores sum analysis

Number of students	Age (mean)	Sex	Weight (mean)	Height (mean)	Pulse Rate (mean)	Resp Rate (mean)	Blood Pressure (mean)	Hari's stress Inventory score 1 month back (mean)	Hari's stress Inventory score7 days back mean
69	17	M	50	168	76	20	108/68	110	166

Summary: The Stress Inventory Assessment reveals personal stress reaction and enables early intervention for stress resolution. Heart Rate Variability is a simple measure of the beat to beat variation of consecutive heart beats and is a measure of the Central Autonomic Outflow to the periphery[6]. Stress, anxiety and depression are associated with reduced HRV [14] with sympathetic dominance and consequential vagal withdrawal. This trend, with a decrease in the energy conserving vagal tone, could explain the increased vulnerability of such a population to stressful events of cardiovascular disease and sudden cardiac events that have been documented in association with psychological states of stress16.

HRV analysis provides an objective status of psychosomatic disturbance of the human body[17]. On comparative evaluation of Examination Stress and Heart Rate Variability significant difference was observed in Low Frequency/High Frequency (LF/HF)ratios of HRV 1month and 7 days before the final examination. Significant appreciable difference could be observed in the amplitude of the waveforms in HF, LF and SDANN of frequency domain of HRV. Perceptible increase in LF/HF ratio and LF power could be observed. A similar decrease (not significant) in HF power was observed just before the examination. So in conclusion there is an increase in LF/HF and LF power and decrease in HF power. However, in the present study amplitude of waveforms of HF and LF region significantly (statistically) changed in situations

of stress and it seems that amplitude of the waveforms of LF and HF region could be a better and sensitive indicator of stress. Significant changes in the amplitude of waveforms of HF and LF region could serve as a sensitive and a coherent indicator of sympathovagal interplay.

Significant changes in SDANN could also be appreciated that suggest the changing RSA rhythm to sympathetic rhythm[15]. An enhanced sympathetic outflow as discerned through increase in LF/HF ratio and LF power with a concomitant decrease in HF power along with significant decrease in SDANN values profiling a decreased vagal outflow portraying the respiratory sinus arrhythmia (RSA) of the student population denotes an autonomic neurophysiologic status that needs a specialist attention in terms of proper and adequate guidance and counselling.

An optimal level of stress within the neurophysiologically permissible range of HRV is essential for optimal physiological performance, though excess levels of stress may become detrimental to the malleable, willowy and nimble mental and physical health of the adolescent. [16.]So the present study gives us an insight into the dynamics of sympathovagal interplay in situations of mental (psychological) stress that is translated and documented into tangible neurophysiologic domains of heart rate variability (HRV).

References:

1. Anuradha Sovani. Chapter 48,52 in Training manual for Adolescent Health, PART 2 Indian perspective.pg.285,298 Organised by IAP Adolescent Chapter with Indian Academy of Pediatrics International Training Program on Adolescent Health, National Task Force on Adolescent care and Michigan State University, Kalamazoo Centre for Medical Studies ,USA, New Delhi,2-7 December ,2002
2. Cacioppo, J.T., Berntson, G.G., Sheridan, J.F. & McClintock, M.K. (2000) Multi – level integrative analyses of human behavior: the complementing nature of social and biological approaches. Psychological Bulletin, 126, 829 – 843.
3. McCraty R, Tomasino D, Atkinson M, Aasen, P, Thurik SJ. (2000) Improving test taking skills and academic performance in high school students using HeartMath learning enhancement tools. Boulder Creek, CA: HeartMath Research Center, Publication No.00-010.
4. Jain, D., Joska, T., Lee, F.A., Burg, M., Lampert, R. & Zaret, B.L. (2001) Day-to-day-reproducibility of mental stress-induced abnormal left ventricular function response in patients with coronary artery disease. Journal of Nuclear Cardiology, 8, 347–355.
5. Jennings, J.R. &Van der Molen, M.W. (2002) Cardiac timing and the central regulation of action. Psychological Research, 66, 337–349.
6. Malik, M. (1998) Heart rate variability. Current Opinion in Cardiology, 13, 36–44. Heart Rate Variability; Standard of measurement, physiological interpretation and clinical use. Task force of the European Society of cardiology and the North Americans society of Pacing and Electro-Physiology, Circulation 1956; 1043-65.47.
7. Porges,S.W.(1995).Cardiac Vagal tone,A Physiological index of stress .Neurosciencse and Behavioral Rev. 19,225-233.
8. Berntson GG, Cacioppo JT, Quigley KS. (1993) Respiratory sinus arrhythmia: autonomic origins, physiological mechanisms, and psychophysiological implications. Psychophysiology, 30, 183 – 96.
9. Hari's stress inventory for students - Dr. Hari S. Chandran, M.Phil (Psy), Ph.D, PGDPC, Consultant Psychologist, Department of Deaddiction and Mental Health, St. Gregorios Mission Hospital, Parumala. Kerala, India. Published by Smashwords. Copyright 2014.
10. Standards of measurement, physiological interpretation, and clinical use. (1996) Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (Membership of the Task Force listed in the Appendix). European Heart Journal 17, 354 – 381.
11. Brosschot, J. F., Van Dijk, E., & Thayer, J. F. (2007). Daily worry is related to low heart rate variability during waking and the subsequent nocturnal sleep period. International Journal of Psychophysiology, 63(1), 39-47
12. Buchheit, M., & Gindre, C. (2006). Cardiac parasympathetic regulation: respective associations with cardiorespiratory fitness and training load. American Journal of Physiology. Heart and Circulatory Physiology, 291(1), H451-458.
13. Grossman P. 1992. Respiratory and cardiac rhythms as window to central and autonomic bio

behavioral regulation: Selection of window frames, keeping the panes clean and viewing neural topography. Biological Psychology, 34,131-16114.
14. Bhatia, B. D. (1982) Mental hygiene in education. IN B. Kuppuswamy (Ed.) Advanced Educational Psychology, Sterling Publishers Pvt. Ltd.
15. Zucker, T. L., Samuelson, K. W., Muench, F., Greenberg, M. A., & Gevirtz, R. N. (2009). The effects of respiratory sinus arrhythmia biofeedback on heart rate variability and posttraumatic stress disorder symptoms: a pilot study. Applied Psychophysiology and Biofeedback, 34(2), 135-143.
16. Gamelin, F. X., Baquet, G., Berthoin, S., Thevenet, D., Nourry, C., Nottin, S., et al. (2009). Effect of high intensity intermittent training on heart rate variability in prepubescent children. European Journal of Applied Physiology, 105(5), 731-738.

Conflict of interest: None

Funding: None

Cite this Article as: Dr Dhan Raj B, Dr Ashok G, Dr Amitabh D, Dr R K Gupta Assessment Of Examination Stress And HRV. Natl J Integr Res Med 2016; 7(4): Page no 1-7