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Original Research Article.

Anxiety and Heart Rate Variability in Adolescents

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ABSTRACT

Background: Anxiety in adolescents is an emerging public health problem throughout the world and its prevalence has increased dramatically over the last decade in both developed and developing countries. The autonomic nervous system (ANS) plays an important role in regulating response of our body to various anxiety provoking situations on short and long term basis. ANS activities can be assessed by many ways, among which heart rate variability (HRV) is easy to measure and is quite reliable also. The aim of this study was to assess HRV among adolescent suffering from anxiety.

Method: This study was carried out in a school at Jaipur. It included 35 adolescents with diagnosis of anxiety disorder, in the age range of ten to nineteen years studying in class 8th to 11th, and 34 suitably matched healthy controls. Heart-rate variability was studied using the standard protocol.

Results: There is significant reduction in HRV in anxious adolescents. Significant increase in LF/HF ratio and LF power and decrease in HF power in cases compare to control.

Conclusion: ANS as a whole is depressed in anxious group of adolescent with particular evidence of parasympathetic depression.

Keywords: Adolescents, Anxiety, Heart Rate Variability.

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INTRODUCTION

The term adolescent is derived from the Latin word 'adolescere' which means 'to grow' or to 'grow to maturity'. Adolescent age group according to WHO is from 10 to 19 years.[1]

A universally accepted definition of adolescence including the various psychological, sociological aspects is yet to be established[2]. Traditionally it is defined as a period from onset of puberty to the physical growth and attainment of final adult height and characters.[2]

Anxiety is one of the most common psychological disorders in adolescents. The prevalence rate ranges from 4.0% to 25.0%, with average rate of 8.0%. These figures could be underestimated since anxiety among adolescents goes undiagnosed owing to the internalised nature of its symptoms.[3]

Anxiety is associated with substantial negative effects on children's social, emotional and academic success. Specific effects includes poor social and coping skills, often leading to avoidance of social interactions, loneliness, low self-esteem, perception of social rejection and difficulty forming friendships. Importantly school avoidance, decrease problem solving abilities and lower academic achievements have also been noted as consequences.

The last two decades have witnessed the recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death.[2] Heart rate variability (HRV) represents one of the markers of association between propensity for lethal arrhythmias and sign of either increased sympathetic or reduced parasympathetic activity. Many commercial devices now provide an automated measurement of HRV, seemingly a simple tool for both research and clinical studies.[4]

HRV is a measure of the continuous interplay between sympathetic and parasympathetic influences on heart rate that yields information about autonomic flexibility and thereby represents the capacity for regulated emotional responding.

We assume that the healthy heart beats regularly but surprisingly it is not so, there is variation in heart rate from one beat to next beat. This beat to beat variability of heart is called HRV. HRV is a simple measure of the beat to beat variation of consecutive heart beats. A decrease in HRV means the beat to beat time interval is more. It has been observed that more even the frequency changes, lower the HRV would be. Conversely, the more uneven the frequency changes greater the HRV. HRV is determined

mathematically by measuring the time between successive beat to beat R-R intervals of QRS complexes as recorded on an electrocardiographic strip. HRV reflects the degree to which cardiac activity can be modulated to meet changing situational demands.

Empirical Research with HRV

- Low HRV is an independent risk factor for several negative cardiovascular outcomes.
- Low HRV is a proxy for underlying cardiovascular disease processes.
- Higher levels of resting HRV have been associated with effective coping strategies.
- Attention control is associated with higher HRV.
- Lower HRV is associated with depression and generalised anxiety disorder.

MATERIALS AND METHODS

It was a cross sectional study done in Department of Pediatrics, S.M.S. Medical College and Attached Hospitals, Jaipur and association with Sri Khandelwal vaishy central senior secondary school, Jaipur after the requisite clearance from the Institute Research Review Board. 200 consecutive healthy male children in age group 10- 19 years studying in class 8 to 11 were subjected to Hamilton Anxiety Scale. All children and their parents were informed about various aspects of the study. A written consent was taken from all of them. The above subjects were then subjected for Hamilton anxiety rating scale. Adolescents with anxiety score > 17 were subjected to HRV. There was 36 adolescent with score >17, father of one adolescent was suffering from heart disease which was consider as oblivious confounding factor so excluded from study. HRV of this group was compare with 34 healthy control groups.

Exclusion Criteria

- Subject under study should not be having any disease/ pathological conditions.
- Ingestion of caffeine containing beverages in last 24 hours.
- Fasting state of more than 3 hours.
- Adolescents on drugs known to affects cardiac autonomic functions like anticholinergics, sympathomimetic and parasympathomimetic agents.

Tools and methods for heart rate variability: this study was done in morning hours from 9.30 Am to 12 Pm in the above mention school. A room was used as laboratory to simulate conditions as laid down by international protocol. The room temperature was maintained at 24 degree Celsius. Adolescents with Hamilton anxiety score>17 were subjected for HRV testing. Following instructions were given to the subjects under study-

1. To avoid food preceding two hours of the testing.
2. No coffee, nicotine or alcohol 24 hours prior to the testing.
3. Drugs known to affect cardiac autonomic functions may be stopped after consultation with paediatrician for 2 days prior to testing.
4. To wear loose and comfortable clothing.

Recording: for short term analysis of HRV, ECG is recorded in supine position for 5 minute after 15 minutes of supine rest. Subjects were instructed to close the eyes and avoid talking; moving hands, body parts or sleeping.HRV was derived from ECG using electrodes placed on chest. The ECG signal is continuously amplified, digitalized and stored in the computer for offline analysis. Processing of ECG was done using HRV software (MICT: AIIMS New Delhi, BARC Mumbai). Quantification of HRV was done by three methods: time domain, frequency domain and non-linear method**s**.

Time domain methods: in this method, statistical tools were applied to quantify the variation in R-R interval and following parameters were computed which detect parasympathetic activity-

SDNN- standard deviation of the R-R interval.

SDSD- standard deviation of difference between adjacent R-R interval.

RMSSD- root square of the mean of the sum of the square of differences between adjacent R-R intervals.

NN50- numbers of R-R interval differences >50 milliseconds.

pNN50- percentage of NN50.

Frequency domain methods: the frequency components of HRV were analyzed by using Fast Fourier Transform method. The power spectrum is subsequently divided into three frequency bands- VLF (0.001 to 0.04) Hz, LF (0.04 to 0.15) Hz, and HF (0.15 to 0.4) Hz. Power spectral densities were plotted in ms^2/Hz against preset frequencies. Power of the spectral bands were calculated in ms^2 (absolute power) and in normalized units (n.u.).

Non Linear method (Poincare plot): the Poincare plot is a scatter plot of current R-R interval against the R-R interval immediately preceding it ($R\text{-}R_n$ Vs $R\text{-}R_{n+1}$). The R-R interval Poincare plot typically appears as an elongated cloud of points oriented along the line of identity at 45^0 to the normal axis.

The conventional parameters on this method are-

SD1- dispersion of point perpendicular to the line of identity.

SD2- dispersion along the line of identity.

SD1/SD2- ratio of SD1/SD2.

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

Anxiety rating scale was applied on 197 students. Out of them 32 (16%) students were found to be free of any kind of anxiety. Since we have taken our cases from 8^{th}, 9^{th}, 10^{th} and 11^{th}. So we presumed them as of average intelligence. 36 students were found to have a score >17 and out of them 1 adolescent was reported to have heart diseases in his father which was considered to be an obvious confounding factor, so excluded from the study, and 34 comparable controls were considered for heart rate variability testing in them. This study reveals significant level of anxiety in adolescents which is almost 18%. As earlier studies[5] showed that anxiety leads to dysregulation of autonomic control of heart leading to increased heart rate and decreased heart rate variability and respiratory sinus arrhythmia. Lower total HRV and cardiac vagal control are found in subjects with anxiety. This coincides with the fact that during anxiety there is sympathetic dominance as was hypothesized in the study.

The average value of central autonomic outflow for adolescents as NN 50 (86.69), pNN 50 (26.88), RMSDD (72.88), SDNN (65.47) & SDSD (72.88) in cases and NN 50 (131.79), pNN 50 (39.40),

RMSDD (107.02), SDNN (86.46) & SDSD (106.19) in control group respectively. This suggests that comparison of HRV in cases and control group depicts significant changes in NN 50 (p = 0.048), pNN 50 (p = 0.080), RMSDD (p = 0.078), SDNN (p=0.077) & SDSD (p=0.078) (table 1). That supplants the belief that the vagal rhythm of RSA (Respiratory Sinus Arrhythmia)[6] is converted into sympathetic rhythm during stress in order to prepare and condition the individual for the imminent needs.

Table 1: Correlation between HRV in case and control group (time domain)

S.N.	Parameters	Case Group (N-35)	Control Group (N-34)	p- value
1	Max R-R interval	1027.43±302.63	1225.82±291.73	0.007
2	Min R-R interval	592.74±97.90	576.24±110.84	0.514
3	Max/min	1.80±7.2	2.24±0.84	0.023
4	Coefficient of variance	7.95±4.85	10.51±5.98	0.055
5	SDNN	65.47±46.42	86.46±50.70	0.077
6	SDSD	72.88±77.45	106.19±77.29	0.078
7	RMSSD	72.76±77.09	106.02±77.29	0.078
8	NN50	86.69±91.54	131.79±94.60	0.048
9	pNN50	26.88±29.35	39.40±29.11	0.080

Table 2: Correlation between HRV in case and control group (frequency domain)

S.N.	Parameters	Case group (N-35)	Control group (N-34)	p-value
1	VLF (% Power)	34.52±19.70	26.59±14.60	0.062
2	LF (% Power)	31.34±13.95	25.24±12.85	0.064
3	HF (% Power)	34.14±23.91	48.17±20.25	0.011
4	Total Power (% Power)	100.00±0.00	100.00±0.00	-
5	LF (Normalised Power)	52.08±24.36	36.07±20.67	0.004
6	HF (Normalised Power)	47.92±24.36	63.94±20.67	0.004
7	LF/HF Ratio	2.07±2.48	1.04±2.02	0.064
8	VLF/LF Ratio	1.44±1.55	1.38±1.33	0.877
9	VLF (Absolute Power)	1426.27±1395.41	2355.61±2807.61	0.085
10	LF (Absolute Power)	1481.58±1287.46	2322.54±2953.29	0.128
11	HF (Absolute Power)	3100.21±4591.99	6341.76±8609.14	0.054
12	Total Power (Absolute Power)	6008.07±6054.42	11019.92±13385.92	0.048

Table 3: Correlation between HRV and LF/HF Amplitude

S.N.	Parameters	Case group (N-35)	Control group(N-34)	p value
1	LF Amplitude	52.08±24.36	31.34±15.82	<0.05
2	HF Amplitude	34.14±21.54	48.17±20.25	<0.05
3	LF/HF Amplitude	2.07±0.85	1.04±1.8	<0.05

Table 4: Correlation between HRV in case and control group (nonlinear domain)

S.N.	Parameters	Case group (N-35)	Control group (N-34)	p value
1	SD1	51.52±54.71	75.08±54.76	0.078
2	SD2	92.33±65.69	122.00±71.72	0.078
3	SD1/SD2	0.46±0.18	0.58±0.12	0.002
4	HRV Triangular Index	0.19±0.07	0.18±0.07	0.412
5	TINN	322.57±253.78	511.38±312.63	0.007

The sympatho-vagal interplay and thermoregulatory central influences in relation to the symphathetic drive (VLF/LF). There is significant change in HF power, LF and HF normalised power and total power. LF/HF ratio is more in case, which validates the role of autonomic system in the determination and possible evolution of neural circuit sub serving the anxiety states (table 2). 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.[7] an interesting observation that validates the state of the autonomics in the determination and possible evolution of the neural circuitry sub serving various stress. 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.[4] Stress, anxiety and depression are associated with reduced HRV 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 stress.

The present study showed that the significant change in amplitude of LF and HF. It indicates the situation of anxiety and serves as sensitive indicator of anxiety (table 3). 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.

Our study showed that the SD1/SD2 ratio represents the sympatho-vagal interplay. We found statistically significant decrease in SD1/SD2 ratio in cases compare to control, which reflects the sympatho-vagal interplay. TINN is also decrease in anxious adolescents suggesting the optimal variability is decrease in anxious group. The HF component is generally defined as a marker of vagal modulation. This components is respiration-mediated and thus determined by the frequency of breathing. 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 counseling.

The LF component is modulated by both the sympathetic and parasympathetic nervous systems. In this sense, its interpretation is more controversial. Some scientists consider LF power, particularly when expressed in normalized units, as a measure of sympathetic modulations; other interpret is as a combination of sympathetic and parasympathetic activity. The consensus is that it reflected a mixture of both autonomic inputs.

CONCLUSION

We concluded that there is significant increase in LF/HF ratio and LF power and decrease in HF power. SD1/SD2 ratio which represents sympatho-vagal interplay is also significantly reduced in anxious group of adolescents as compared to non-anxious group.

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