JPSIM Journal of Pakistan Society of Internal Medicine

Original Article

Correlation between Heart Rate Variability and Intelligence Quotient in Medical Students of Pakistan: An Exploratory Study

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Abstract

Objective: To determine a correlation between autonomic systemic variability through measurement of time Domain HRV and intelligence quotient (high and average IQ) of medical college students.

Methods: It was a cross sectional study conducted at The Central Park Medical College Lahore. A total of 34 MBBS students participated. Modified Wechsler Adult Intelligence Scale (WAIS) was used to calculate the IQ of students. Assessment of autonomic function was done by determination of HRV through variables of time-domain using Lab Chart version 8.0 with HRV module installed. It utilized Data Acquisition System with application of ECG two limb leads. Mann-Whitney U test used to compare median values. Spearman's correlation was used to find any correlation.

Results: In our study population RMSDD, SDRR and pRR50% were compared with reference values and it was observed that our study population HRV Indices were much higher than the reference values, but the difference did not reach significance. No correlation was found between HRV of average and high IQ medical students.

Conclusion: Time domain of Heart rate variability was much higher in the medical students as compared to the reference values, but it did not reach statistical significance when compared between average and high IQ students.

Key Words: Heart rate variability, Intelligence Quotient

How to cite this:

Lodhi HN, Baig AA, Nisa M, Mehmood F, Younas W, Omar N. Correlation between Heart Rate Variability and Intelligence Quotient in Medical Students of Pakistan: An Exploratory Study. J Pak Soc Intern Med. 2024;5(4): 711-715

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Received: 25-03-2024 **Accepted:** 02-11-2024

DOI: https://doi.org/10.70302/jpsim.v5i4.2470

Introduction

Heart rate variability (HRV) indicates changes in intervals of time between successive heartbeats. It is calculated by interfaces between the two parts of the autonomic nervous system i.e sympathetic and parasympathetic.[1]

It's known that these two system's functions are antagonistic to each other. When there is an increase in SNS predominance raises heart rate, an increase in parasympathetic nervous system has an opposite effect. The SNS controls the fight-or-flight reaction in a multitude of situations, while the parasympathetic nervous system is for resting in a calm environment. Due to these constant opposing inputs from the sympathetic and parasympathetic systems, the rhythm of heart sways cyclically all the time around the mean heart rate[2]. By measuring this fluctuation, we can determine the balance between these two systems. The signals from the baroreceptors, in the internal carotid arteries and the aorta, would react to the command of the heart requirements as a reaction to stress felt by the body. These are varied such as levels of blood pressure, heart rate etc. All these responses can be calculated by changes in heartbeats which can be characterized using HRV. Recent evidence advocated that it might be an indicator for the normal working of the medial portion Pre-Frontal Cortex.[3]

Lower finding on variability indicates disfunction of the autonomic system and has been linked with lower scores on test of cognitive.[1] Poor test score of cognition tests linked with decreased HRV may be a result of factors linked with HRV or the absence of proper regulation of brain perfusion by the autonomic nervous system. Recently there is revival of interest regarding relationship between HRV and intellect with study pointing out that dysfunction in autonomic system may occur prior

to the development of intellectual impairment. The relation between them is not yet clear.[2]

The actions of the autonomic nervous system can be estimated by HRV.[4,5] HRV, in R-R intervals, has been acclaimed as a new way of calculating and detecting risk posed to health in current time. HRV is like the function of human ANS.[6] Aging affects the cognitive functions of the human brain to such an extent that it could affect an individual's social as well as daily life activities. The need to detect early biomarkers of changes in cognitive functions in the background of a shift in social and demographic conditions all over the world, such an increase in aging population is on the rise. Autonomic dysfunction has a negative impact on the cognitive abilities of an individual.[7,8] Keeping this in viewpoint, a good correlate of intellectual functioning is HRV that is already a marker of hearts autonomic control.[7,9,10]

Since the vagal tone of heart is linked to cognitive control by several previous studies considering parasympathetic activity of heart is required for adaptation to environmental changes[7,11-14]. A link between HRV and intellectual performance has been registered. One study failed to determine a relationship between these two. Specifically, a low HRV was linked to worse test scores[15-21]. People with higher HRV levels have a better capability to control memory and to stem unrequired memories[22]. Low HRV has been connected with a poor score in verbal memory[23,24]. However, some studies could not find any link between verbal[15,21] or visuospatial memory[23] and HRV.

A research study conducted to expand the literature on HRV in cognitive performance score and tests examined whether a refined threat cue in a testing environment had an impact on HRV and whether this is linked with changes in intellectual performance scores. This study pointed out a plausible direct relationship between these two parameters. They concluded that poor performance on IQ test was observed after exposure to a threat cue that lowered the subjects HRV. Previous literature emphasizes the role of autonomic variability and intellectual functions. The data on this aspect is still scarce. Still, it is possible to consider HRV a new early biomarker of cognitive impairment in groups of people that do not have stroke or dementia. HRV indices can be utilized in the future for early prevention of such conditions as well.[24]

By measuring physiological markers such as HRV and IQ, a measure of cognitive abilities, we can explore whether there is a correlation between autonomic nervous system activity and cognitive performance among medical college students. Assessing heart rate variability and intelligence quotient in medical college students can provide valuable insights into the potential relationship between physiological and cognitive functioning.

Methods

This study was conducted at The Central Park Medical College Lahore. It was a cross-sectional study. As the study was exploratory in nature with the study group being a pool of first and second year MBBS students, a non-probability sampling technique was utilized. This meant that we performed convenience sampling of all first- and second-year medical students who volunteered for the study. After approval from the institutional review board, we collected data. A total of 34 MBBS students volunteered to participate. Written informed consent was taken on a predesigned proforma. Modified Wechsler Adult Intelligence Scale (WAIS) was used to calculate the IQ of students. The students were brought to the digital library and asked to fill in a time bound IQ assessment questionnaire that had 20 questions. The software of the test automatically generates the IQ score of each of the participants. These scores were recorded on the biodata proformas.

Assessment of autonomic function was done by determination of HRV by calculating time-domain variables. This is the simplest method of calculating autonomic function. HRV was recorded with a noninvasive feedback technique at rest in the lying down position in a private area of the laboratory. We used Lab Chart version 8.0 with HRV module installed. It utilized Data Acquisition System with application of ECG two limb leads. The following time-domain HRV parameters were of interest and calculated in the software and values recorded in separate proformas: RMSSD (square root of mean of squares of difference between successive RR intervals). The parameter has to do with shorter term variability. SDRR (Standard Deviation of RR interval), PR50% (percentage of successive intervals that are differing by more than 50 ms), SDRR (The standard deviation of the RR interval), CVRR (coefficient of variation of RR intervals), Average RR and Median RR. All the foregoing parameters were measured in milliseconds. A p-value of 0.05 was taken as suggestive of statistical significance.

Results

A total of thirty-four students, 18-22 years, voluntarily participated in the current study. There were 23 (67%) males and 11 females (32.4%). The normality was tested by Shapiro-Wilk test. Data was not normally distributed, so we applied Mann Whitney U test to compare median values. The median IQ of study population was 100. Most (26%) of the students had a normal IQ in range of 90-109 (Table 1).

The median split method was used to categorize students into two groups as having high (n=19, IQ score >100) and average IQ (n=15, IQ score< 100) groups. Median IQ of high was 121.27(18.280) and of IQ low was 89.48

(18.28). The HRV indicators recorded and calculated in the time domain are shown in table 2. These included included Average RR, SDRR, SD Rate, Median RR Average rate, SD Rate, CVRR, SDSD, RMSSD and pRR 50%. Comparison between Average and High IQ groups and Time domain Heart rate Variability Indices using Mann-Whitney U test. The simplest and most reliable way for determination of heart rate variability especially for large scale calculations is by Root Mean Square of the difference between every heartbeat (RMSSD). It measures the autonomic variability as well as the status of parasympathetic activity.

We compared normal reference values of RMSDD, SDRR and pRR50% with available median reference values using one sample Wilcoxon signed rank test. Our HRV Indices were much higher than the reference values, but the difference did not reach significance as shown in table 3.

Comparison of study population with normal refence values using One sample Wilcoxon signed rank test.

Spearman's correlation was used to find any correlation, but it also did not reach significance as shown in table 4.

Table 1: *Interpretation of IQ scores.*

IQ	Interpretation
130 and above	very superior
120 - 129	superior
110 - 119	High average
90 -109	Average
80 - 89	Low average
70 79	Boderline
69 and below	Extremely Low

Table 2: *Comparison between Average and High IQ groups*

HRV indicator (ms)	Group A(n=19) Mean	Group B (n=15) Mean	p-value
SDRR	60.012	54.439	0.768
RMSSD	46.608	35.562	0.931
PRR50	17.821	15.875	0.849
SDRR	60.012	54.439	0.327
CVRR	.0794	.0748	0.615
Average RR	720.789	730.520	0.239
Median RR	720.157	728.633	0.239

Table 3: *Comparison of study population with normal*

Time Domain HRV Indices	Study population value (Group A and B)	Normal reference value	p-value
RMSDD (ms)	41.73(34.398	27(2)	0.052
SDRR (ms)	57.55(29.5)	56.39	0.427
PRR50% (ms)	16.963(19.4)	13.1(4)	0.898

Table 4: *Correlation between IQ scores and HRV indices*

Time Domain HRV Indices	RMSDD (ms)	SDRR (ms)	pRR50% (ms)
Spearman's Correlation coefficient	0.72	1.39	0.86
p-value	0.687	0.434	0.629

Discussion

Heart variability and intelligence quotient are interrelated and under study in the recent years. Our, study aimed to investigate the relationship between first-year medical students' intelligence quotient and their cardiac autonomic activity by measuring their HRV indices. In our study we observed a high HRV in students with high IQ levels as supported by literature with no correlation. Although the HRV indices in our study did have much higher values than the reference values reported by an Indian study[6] but the difference between these two did not reach statistical difference. IQ and academic performance are interdependent, as observed in a cohort study conducted on first year medical students in India measuring personality traits, heart rate variability and resting heart rate. Although relationship was evident but statistically significant correlation between academic performance, resting heart rate and HRV indices was not established. Many studies exhibited an association between poor academic performance and lower HRV15, however two other studies19 did not confirm these findings.

Association between HRV and executive functions encompassing both time and frequency domains has been studied as observed in literature on large samples[26,20,21]. Relationship of different executive functions and HRV was confirmed[21,27,28,29]. A study witnessed comparison within subjects with high and low HRV (indexed by RMSSD) in resting state, demonstrating a better action cascading and highlighting an association between best function of the prefrontal-subcortical inhibitory circuits that bear responses to demands of the environment and high resting HRV.[29] Cognitive functioning and HRV domains did not depict any correlation even on large samples of people with common characteristics as other studies, a contrast to the literature.[15]

Inconsistency within studies maybe due to diversity and variability within the data, attributed to the methodologies adopted. In the prospective studies enrollment of participants in phases which may have led to selection bias. Male predominance (72%) may be considered as another reason for the contrasting results. Studies support

more RR interval, more LF-HRV and decreased HF_ HRV in males compared to females.[29] Poor performance was predicted with low HRV on tasks encompassing executive functions. This prediction was independent of clinical, behavioral and demographic confounding variables.

A constraint of our study was the homogeneity of the study population chosen and therefore limiting the generalizability of results. Medical students enrollment can lead to selection bias, as HRV and IQ may be by factors such as personality traits, genetic makeup and stress levels which were not excluded. Additional investigations in appropriate student populations will further establish and unravel the nuances in the relationship between intelligence quotient and objective markers of cardiac autonomic functioning.

Conclusion

Heart rate variability was much higher in the medical students as compared to the reference values but it did not reach statistical significance when compared between average and high IQ students.

Recommendation: Conduct further studies on larger sample size.

Ethical Approval: The IRB/EC approved this study via letter no. CPMC/IRB-NO/1392 dated 14-03-2023.

Conflict of Interest: None

Funding Source: None

Authors' Contribution: Role and contribution of authors followed ICMJE recommendations

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