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Original Research Article

Assessment of the Impact of Gender on Cardiac Autonomic Function as Determined Through Heart Rate Variability Analysis

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Abstract

Background: Heart rate variability (HRV) is considered an indicator of cardiovascular health. Women generally show a lower risk of coronary heart disease and serious arrhythmias compared to men, with a significant delay in the incidence of sudden death. This disparity suggests potential gender differences in autonomic modulation. We in the current study aimed to evaluate the Heart rate variability in young adult male and female students of our institute.

Methods: The study involved 120 participants (60 males and 60 females). We measured anthropometric parameters such as age, height, weight, and BMI. Baseline characteristics, including resting heart rate and systolic and diastolic blood pressure, were recorded during five minutes of supine rest. HRV parameters like total power, low frequency, low frequency normalized units, high frequency, high frequency normalized units, and low frequency/high-frequency ratio were analyzed using ECG recordings.

Results: Males have a significantly higher LF power in milliseconds squared (ms^2) compared to females (p=0.023). This suggests greater sympathetic activity or response to stress in males. While the average normalized LF power (nu) is also higher in males, the p-value (0.051) is borderline significant. It suggests a possible trend but needs further investigation. Females have a significantly higher HF power in ms^2 compared to males (p=0.019).

Conclusion: Our study shows that there are possible gender differences in heart rate variability (HRV) among young healthy individuals. Males were more likely to have low frequencies which might be being regulated sympathetically. This corresponds to the previous findings that sympathetic dominance might be related to the cardiovascular disease risk.

Keywords: Heart Rate Variability, Autonomic Nervous System, Cardiovascular Disorders, Autonomic Modulation, Gender Differences.

Introduction

The autonomic nervous system is an essential component in the regulation of the cardiovascular system under normality and stressful situations. HR and its variations serve to point out changes in cardiac autonomic control. These links constitute a platform for the study of cardiac autonomic function based on the measurement of heart rate variability (HRV) [1]. There is an increased acceptance of Heart rate variability which entails the beat-to-beat variations in the R-to-R interval as a means of assessing the autonomic influence on the heart in both healthy and diseased conditions [2, 3]. The decreased HRV is associated with several vascular disorders such as coronary atherosclerosis, coronary artery disease, and congestive heart failure. HRV (heart rate variability) is the irrefutable non-invasive measure for assessing cardiac autonomic function. [4] It is a critical indicator of both mortality and morbidity among healthy and sick populations, reflecting the harmonious combination of biological factors that regulate heart rate, thus proving the complex relationship between neuronal regulatory mechanisms and the sinoatrial node function. [5]

Reduced levels of HRV have been linked to a large number of medical and mental difficulties. HRV, an abbreviation for Heart Rate Variability, determines the body's capacity to respond to different physical or mental stimuli and represents a simple and non-invasive option to assess cardiac autonomic function. [6] For short-term evaluation of HRV, frequency domain methods are more widely used because they are simple and rely on spectral analysis. Typically, three spectral bands are identified: the HF component (0.15 - 0.4 Hz), which has an association with respiratory-induced heart rate variations and is mainly modulated by the vagal nerve; the LF component (0.05-0.15 Hz), which is believed to be modulated by the activities of both the sympathetic and the parasympathetic systems; and the VLF component predominantly governed LF and HF segments are scaled in the normalization units to ensure that the overall distribution is uniform. The LF/HF ratio demonstrates the relationship between the sympathetic and parasympathetic systems. A reduced HRV is a threshold sign of stress and a decline of the vagal influence on the heart, which increases the risk of cardiovascular diseases and arrhythmias. [7, 8] The purpose of the study was to differentiate the “time domain” parameters of “heart rate variability” in male and female medical students at our institute.

Material and Methods

This cross-sectional study was done in the Department of Physiology. A total of 120 healthy participants, balanced between genders and aged 20-25 years, were recruited for the study. The included subjects were all non-smoking individuals with no chronic diseases or allergies. Those with hypertension, asthma, or diabetes were not admitted into the study. Each participant provided written informed consent and was asked to arrive at the Physiology Lab between 8:00 and 9:00 AM, having avoided coffee and tea for at least twelve hours. The participant's body weight was recorded, patients relaxed for five minutes, and their blood pressure was measured using a mercury sphygmomanometer. HRV readings were taken during a ten-minute ECG session in a silent room where the subjects were seated in a comfortable position. Heart rate variability (HRV) is usually evaluated as a variation of heart rate during a specific period or different frequencies. A time domain analysis is often applied for HRV and is known as RMSSD which means Root Mean Square of Successive Differences between heartbeats. With this method, it is simple to calculate and truly measure HRV and the activity of the sympathetic nervous system parasympathetic. Among time-domain methods, the others are SDNN and SDANN. SDNN is the standard deviation of all RR intervals (which are the intervals between heartbeat or R in QRS complex on ECG). SDANN, in turn, is based on measuring the average RR interval over several 5-minute contiguous recording segments and then the standard deviation of these averages. In Frequency-domain analysis, the LF heartbeats (0.04 to 0.15 Hz) would be considered as the sign of the involvement of the sympathetic nervous system. High frequency (HF; 0.15 to 0.4 Hz) measurements characterize activities of the parasympathetic nervous system. Indeed, these frequencies are not closely linked to heart rate but concern HRV modulation instead. Also, the HF/LF ratio of HF to LF may help us to understand the state of the sympathetic and parasympathetic nervous systems.

Statistical Analysis: All the available data was uploaded to an MS Excel spreadsheet and analyzed by SPSS version 21 in Windows format. The continuous variables were represented as mean, standard deviation, and percentages. Categorical variables were calculated by independent sample t-test was used to examine differences between male and female groups, with a p-value of ≤ 0.05 considered significant.

Results

A total of 120 subjects were included in the study which included 60 males and 60 females. Table 1 summarizes heart rate variability (HRV) data for males and females included in a study. There's a slight difference in average age (22.25 years for males vs. 21.47 years for females), but the p-value (0.257) suggests it's not a statistically significant difference. Males have a slightly higher average weight (66.67 kg) and BMI (26.67 kg/m²) compared to females (64.28 kg and 25.49 kg/m²), but again, the p-values (0.197 and 0.224) indicate these are not statistically significant differences. Both systolic and diastolic blood pressure are slightly higher in females (120.22 mmHg systolic, 78.42 mmHg diastolic) compared to males (118.63 mmHg systolic, 77.19 mmHg diastolic). However, the p-values (0.741 and 0.221) suggest these are not significant. The average heart rate is slightly higher in males (83.34 bpm) compared to females (82.17 bpm), but the p-value (0.314) indicates this difference is not statistically significant.

Table 1: Comparison of parameters recorded in 60 males and 60 females for HRV analysis included in the study

Parameter	Gender	Mean	SD	P value
Age	Male	22.25	5.65	0.257
	Female	21.47	6.24	
Weight (Kg)	Male	66.67	11.27	0.197
	Female	64.28	10.24	
BMI (kg/m^2)	Male	26.67	0.724	0.224
	Female	25.49	0.518	
Systolic BP (mmHg)	Male	118.63	5.24	0.741
	Female	120.22	6.61	
Diastolic BP (mmHg)	Male	77.19	5.34	0.221
	Female	78.42	5.27	
Heart Rate (min)	Male	83.34	6.40	0.314
	Female	82.17	5.09	

Table 2 shows the comparison of mean parameters of HRV recorded in males and females of the study. Males have a significantly higher LF power in milliseconds squared (ms^2) compared to females (p=0.023). This suggests greater sympathetic activity or response to stress in males. While the average normalized LF power (nu) is also higher in males, the p-value (0.051) is borderline significant. It suggests a possible trend but needs further investigation. Females have a significantly higher HF power in ms^2 compared to males (p=0.019). This suggests greater parasympathetic activity or relaxation response in females. Similar to LF (nu), normalized HF power (nu) is also higher in females, and the p-value (0.022) suggests a statistically significant difference. This aligns with the finding in HF (ms^2). While the LF/HF ratio is numerically lower in females, indicating potentially better parasympathetic dominance, the p-values (0.147 and 0.152) suggest these differences are not statistically significant. Males might have a stronger sympathetic response based on the higher LF power. Females might have a more prominent parasympathetic response based on the higher HF power.

Table 2: Shows the comparison of HRV parameters recorded in males and females

HRV parameters	Males	Females	P value
LF in (ms^2)	440.21 ± 194.33	395.15 ± 113.08	0.023
LF in nu	80.09 ± 7.24	75.49 ± 10.37	0.051
HF in (ms^2)	137.55 ± 41.29	161.20 ± 50.27	0.019
HF in nu	23.37 ±3.47	27.71 ± 5.42	0.022
LF/HF ratio	3.34 ± 0.97	2.46 ± 0.46	0.147
LF/HF nu	3.97 ± 1.10	2.94 ± 0.61	0.152
SDNN in ms	39.02 ± 5.76	43.92 ± 7.84	0.103

Discussion

The previous studies were mainly focusing on the comparison of the cardiovascular autonomic function test across different disease states but there were fewer studies in the area of healthy individuals. As a result, the study set out to examine whether there were any gender differences between the two tests. HRV indicators are the autonomic heart balance ones and contribute to the regulation of blood pressure, gut function, and others. [9] Studies showed that all frequency domain variables in males were generally higher than in females, but these differences were not statistically significant except for the HF parameter. Surprisingly, females had slightly improved values for rMSSD and SDNN compared to their male counterparts, but this was not significant. The HF frequency band that includes parasympathetic also than sympathetic activity, and it primarily reflects the heart rate changes with the respiratory cycle. Thus, the LF power, instead of sympathetic cardiac tone, is linked to baroreflex sensor responsiveness. Lots of medications were understood to be linked to cardiac autonomic function by enhancing baroreflex outputs. The sympathetic activity is signalled by the reduced LF/HF ratio. [10] This work points to the direction that males may show a sympathetic dominance and females an opposite parasympathetic one, but these results did not achieve statistical significance. The explanation for the absence of remarkable findings could be the small number of individuals. The extent of irregularities in HRV parameters is well established in various diseases that may amplify the HRV parameters with an associated higher risk of autonomic dysfunction, which could lead to an increase in morbidity and mortality. Numerous studies have observed differences in gender-led heart rate variability (HRV) in females and observed that females would generally have a higher HRV than males. In a similar study, Balewgizieet al. [11] found that the RMSSD score is higher in females, which means that the parasympathetic system, in this case, is more dominant. Increased expressions of the parasympathetic nervous system in women are suggested by higher HF and lower LF/HF ratios, which may explain the lower occurrence of cardiovascular disease in women.

Al Mohammed et al. [12] found a lower standard deviation for normal R-R intervals (SDNN) time domain HRV measurement in women compared to men. Giannotti et al. [13] observed lower high frequency (HF) power in postmenopausal women compared to premenopausal women and men. Correspondingly, they found that men demonstrate higher sympathetic nervous system activity and women possess parasympathetic dominance referring to frequency domain parameters of HRV therefore, men are showing higher sympathetic nervous system activity and women are manifestation parasympathetic dominance, in accordance with frequency domain parameters of HRV. The normal hypertensive pattern demonstrates that this scenario holds for both unimpaired individuals and those with hypertension. Similarly, Voss et al. [14] found that compared to males of the same age groups, females tended to have a lower absolute LF power within the 25–44-year age group, but a higher absolute HF power during the 35–54 year age range. These insights bring in the notion of the delicate dance between gender-specific physiological reactions and cardiovascular system regulation. Dutra et al. [15] found that females had lower HF and higher LF values and demonstrated that there is a difference between sexes in cardiovascular autonomic balance, in which females are found to have greater cardiac parasympathetic (vagal) influence than males. The findings of this study support the results of this study. Bhowmick et al. [16] evaluated the fact that in female species, the incidence of parasympathetic responses was higher than that in males, whereas sympathetic responses were dramatically higher in males and, in certain situations, higher in females.

Previous research strongly asserts the existence of sex-related biofeedback differences, as demonstrated by Kapoor et al. [17], who concluded that men are more prone to sympathathic hyperactivity than women. Such an increase in sexual desire may be attributed to the secretion of more testosterone and catecholamines in men. Nayak et al. [18] reported that younger working males have a higher Body Mass Index (BMI) and greater sympathetic activity, with lower parasympathetic activity (rest-and-digest response) than females of the same age group. However, this difference was not significant among middle-aged individuals. This may be a result of the relationship between estrogen and blood vessels, which might be different after menopause. In addition, Zachariah et al. [19] showed that there was no significant difference in HRV between males and females at rest (in both time and frequency domain analyses). However, during mental stressor males displayed a prominent sympathetic activity. This implies that sex plays a role in modulation of HRV, which in turn may lead to men exhibiting a stronger sympathetic response, especially when they are under stress. On the contrary, there is lack of uniformity in the results for age and endocrine factors, so more research is needed in this area.

Conclusion

Our study shows that there are possible gender differences in heart rate variability (HRV) among young healthy individuals. Males were more likely to have low frequencies which might be being regulated sympathetically. This corresponds to the previous findings that sympathetic dominance might be related to the cardiovascular disease risk. Nevertheless, large observational studies are needed to confirm these findings and to provide a clearer picture of how HRV, gender, and cardiovascular health are related.

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