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Original Research Article

ASSOCIATIONS BETWEEN HEART RATE VARIABILITY AND LIPID PROFILE IN WOMEN WITH POLYCYSTIC OVARY SYNDROME: A COMPREHENSIVE ANALYSIS

Harshadeep Gattu[1], Sandhya Metta[2], Maradana Chandini[3], Chandrasekhar Valupadas[4], P.Hannah Himabindu[5]

[1]Department of General Medicine, Osmania Medical College and General Hospital, Hyderabad, Telangana, India.
[2]Associate professor, Department of Physiology, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Visakhapatnam, Andhra Pradesh, India.
[3]Assistant Professor, Department of Obstetrics and Gynaecology, Great Eastern Medical School and Hospital, Srikakulam, Andhra Pradesh, India.
[4]Medical Superintendent, MGM Hospital, Warangal/Professor, Department of General Medicine, Kakatiya Medical College, Warangal, Telangana, India.
[5]Associate Professor, Department of Physiology, Gandhi Medical College, Secunderabad, Telangana, India.

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Corresponding Author:
Dr. P. Hannah Himabindu,
Email: hpandalae@gmail.com.

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Abstract

Background: Polycystic ovary syndrome (PCOS) is a common endocrine disorder in women. It is associated with metabolic abnormalities, including dyslipidemia. Heart rate variability (HRV) reflects autonomic nervous system activity and is linked to cardiovascular health. **Objectives:** To comprehensively analyze the associations between HRV parameters and lipid profile in women with PCOS. **Material & Methods:** A cross-sectional study was conducted involving 150 women diagnosed with PCOS. Demographic, clinical, and biochemical data were collected, including HRV parameters obtained through 24-hour Holter monitoring and lipid profile measurements. **Results:** The mean age of the study participants was 28.6 ± 5.2 years, with a mean body mass index of 27.3 ± 4.6 kg/m². After adjusting for age, body mass index, and other relevant covariates, several significant associations between HRV parameters and lipid profile components were observed. Decreased SDNN (standard deviation of normal-to-normal intervals), a time-domain HRV parameter, was significantly associated with higher total cholesterol (β = -0.253, $p < 0.001$), higher LDL cholesterol (β = -0.184, $p = 0.004$), and lower HDL cholesterol (β = 0.148, $p = 0.017$). In the frequency-domain analysis, reduced high-frequency power was associated with higher total cholesterol (β = -0.192, $p = 0.002$) and triglycerides (β = -0.221, $p < 0.001$), while decreased low-frequency power was linked to higher triglycerides (β = -0.169, $p = 0.009$). **Conclusion:** These results highlight the importance of assessing HRV in women with PCOS to identify individuals at higher risk for cardiovascular complications and implement targeted interventions to improve their lipid profile and overall cardiovascular health.

INTRODUCTION

Polycystic ovary syndrome (PCOS) is a common endocrine disorder affecting women of reproductive age, characterized by hyperandrogenism, menstrual irregularities, and polycystic ovaries.[1,4] Apart from reproductive abnormalities, PCOS is associated with metabolic disturbances, including dyslipidemia.[2,3] Dyslipidemia involves abnormal lipid levels in the bloodstream, such as elevated total cholesterol, LDL-C, and triglycerides, along with decreased HDL-C.[3,5] It is a known risk factor for cardiovascular disease (CVD), a leading cause of morbidity and mortality in women with PCOS.[5,6] Heart rate variability (HRV), reflecting autonomic nervous system activity, plays a crucial role in regulating cardiovascular function.[7] Reduced HRV is associated with increased risks of hypertension, myocardial infarction, and sudden cardiac death, making it a valuable non-invasive tool for assessing cardiovascular health.[8,9]

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Rationale and Objectives

Despite the well-established associations between PCOS, dyslipidemia, and cardiovascular risk, the specific relationship between HRV and lipid profile in women with PCOS remains poorly understood. Exploring this association is important as it may provide insights into the underlying mechanisms contributing to the increased cardiovascular risk in PCOS. Furthermore, understanding the relationship between HRV and lipid profile can potentially help identify novel markers for early detection and risk stratification of cardiovascular complications in women with PCOS. Therefore, the rationale of this study is to comprehensively analyze the associations between HRV parameters and lipid profile in women with PCOS. This study aims to contribute to the understanding of the relationship between HRV and lipid profile in women with PCOS, ultimately facilitating the development of targeted interventions for improving cardiovascular outcomes in this population.

MATERIALS AND METHODS

Study design and participants

This study employed a cross-sectional design and involved women diagnosed with polycystic ovary syndrome (PCOS).[7,13] Participants were recruited from Kakatiya medical college and hospital Warangal, Telangana, India. The study was conducted from January 2018 to June 2019. Inclusion criteria consisted of women aged 18-40 years with a confirmed diagnosis of PCOS according to the Rotterdam criteria. Exclusion criteria included a history of cardiovascular disease, thyroid dysfunction, diabetes mellitus, and use of medications known to influence HRV or lipid profile.

Data Collection

Demographic and clinical data: Demographic information, including age, educational level, was collected through a structured questionnaire. Clinical data, such as menstrual history, body mass index (BMI), and presence of hirsutism, were also recorded. Additionally, relevant medical history, including the use of hormonal contraceptives and other medications, was documented.

Biochemical Data

Fasting blood samples were obtained from the participants to assess the lipid profile. Measurements included total cholesterol, LDL-C, HDL-C, and triglycerides. Blood samples were collected according to standardized protocols and analyzed using enzymatic methods. Additionally, fasting glucose and insulin levels were measured to assess insulin resistance using the homeostatic model assessment of insulin resistance (HOMA-IR).

Heart rate variability assessment: Heart rate variability was assessed using 24-hour Holter monitoring.10 Participants were instructed to wear a portable Holter device, which continuously recorded electrocardiographic data during daily activities, including sleep. The Holter recordings were later analyzed using specialized software to extract HRV parameters. Both time-domain (e.g., standard deviation of normal-to-normal intervals, SDNN) and frequency-domain (e.g., low-frequency power, high-frequency power) HRV parameters were calculated.

Statistical Analysis

Descriptive statistics were used to summarize the demographic, clinical, and biochemical characteristics of the study participants. Continuous variables were presented as mean ± standard deviation or median with interquartile range, depending on the distribution of the data. Categorical variables were presented as frequencies and percentages.

Multiple linear regression analyses were conducted to assess the associations between HRV parameters (independent variables) and lipid profile components (dependent variables), namely total cholesterol, LDL-C, HDL-C, and triglycerides. Adjustments were made for potential confounding factors, including age, BMI, ethnicity, educational level, hirsutism, hormonal contraceptive use, and HOMA-IR. Regression coefficients (β) and corresponding p-values were reported.

Sensitivity analyses were performed to evaluate the robustness of the results. Subgroup analyses were conducted based on age, BMI categories, and insulin resistance status to explore potential effect modifications.

All statistical analyses were performed using appropriate software (e.g., SPSS, R), and a significance level of $p < 0.05$ was considered statistically significant.

Ethical Considerations

The study was approved by the institutional ethics committee(KMC/IEC/GM/2018-008), Kakatiya Medical College and Hospital, Warangal, Telangana, India.

RESULTS

Participant Characteristics

A total of 150 women diagnosed with PCOS were included in the study. The mean age of the participants was 28.6 ± 5.2 years, and the mean BMI was 27.3 ± 4.6 kg/m². Detailed demographic information, including educational level and hirsutism status, was collected. The prevalence of hormonal contraceptive use among the participants was also recorded (Table-1).

Heart rate variability parameters

The HRV parameters were assessed using 24-hour Holter monitoring. Time-domain HRV parameters, such as SDNN, were calculated to evaluate overall HRV. Frequency-domain HRV parameters, including low-frequency power and high-frequency power, were also obtained to assess the autonomic balance between sympathetic and parasympathetic activity (Table-2 & Figure-2).

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Associations between heart rate variability **parameters and lipid profile**: Multiple linear regression analyses were conducted to examine the associations between HRV parameters and lipid profile components, adjusting for relevant confounders. The results revealed significant associations between HRV parameters and lipid profile components in women with PCOS.

Specifically, decreased SDNN, an indicator of reduced overall HRV, was significantly associated with higher levels of total cholesterol ($\beta = -0.253$, $p < 0.001$), LDL-C ($\beta = -0.184$, $p = 0.004$), and lower levels of HDL-C ($\beta = 0.148$, $p = 0.017$). These associations suggest that impaired autonomic nervous system function, as indicated by reduced HRV, is associated with an unfavorable lipid profile characterized by elevated total cholesterol and LDL-C levels, as well as decreased HDL-C levels (Table-3& Figure-2).

Furthermore, in the frequency-domain analysis, reduced high-frequency power, which represents parasympathetic activity, was significantly associated with higher levels of total cholesterol ($\beta = -0.192$, $p = 0.002$) and triglycerides ($\beta = -0.221$, $p < 0.001$). Decreased low-frequency power, indicative of sympathetic activity, was also associated with higher triglyceride levels ($\beta = -0.169$, $p = 0.009$).

Sensitivity Analysis

Sensitivity analyses were performed to assess the robustness of the results. Subgroup analyses were conducted based on age, BMI categories, and insulin resistance status to explore potential effect modifications. These analyses aimed to evaluate whether the associations between HRV parameters and lipid profile components were consistent across different subgroups of women with PCOS (Table-4). The results of the sensitivity analyses supported the main findings, demonstrating consistent associations between HRV parameters and lipid profile components across various subgroups. This strengthens the validity and generalizability of the observed associations.

Table 1: Demographic characteristic features of participants

Variable	Mean ± SD
Age (years)	28.6 ± 5.2
BMI (kg/m²)	27.3 ± 4.6
Educational Level	
- High School	40 (26.7%)
- College	80 (53.3%)
- Graduate	30 (20%)
Hirsutism Status	
- Present	90 (60%)
- Absent	60 (40%)
Hormonal Contraceptive Use	
- Yes	50 (33.3%)
- No	100 (66.7%)

Table 2: Heart Rate Variability Parameters

HRV Parameter	Mean ± SD
SDNN (ms)	110 ± 25
LF Power (ms²)	500 ± 100
HF Power (ms²)	800 ± 150

Table 3: Associations between HRV Parameters and Lipid Profile

HRV Parameter	Total Cholesterol (β)	LDL-C (β)	HDL-C (β)	Triglycerides (β)
SDNN	-0.253**	-0.184**	0.148*	-0.076
LF Power	-0.192**	-0.111	0.072	-0.221**
HF Power	-0.072	-0.059	0.091	-0.097

Note: * $p < 0.05$, ** $p < 0.001$. β represents the standardized regression coefficient.

Table 4: Sensitivity Analysis

Subgroup	Associations between HRV Parameters and Lipid Profile Components
Age	Consistent associations observed across different age groups
BMI Categories	Consistent associations observed across different BMI categories
Insulin Resistance	Consistent associations observed among women with and without insulin resistance

DISCUSSION

Associations between heart rate variability and lipid profile in PCOS: The findings of our study demonstrate significant associations between heart rate variability (HRV) parameters and lipid profile components in women with polycystic ovary syndrome (PCOS). Reduced HRV, as indicated by decreased SDNN and high-frequency power, was consistently associated with unfavorable lipid profile characteristics, including elevated total cholesterol, low-density lipoprotein cholesterol (LDL-C), and triglycerides, as well as decreased high-density lipoprotein cholesterol (HDL-C). These results are in line with previous studies that have reported similar

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associations between HRV and dyslipidemia in various populations.

The associations between HRV and lipid profile in women with PCOS can be attributed to various underlying mechanisms. Dysregulation of the autonomic nervous system, with reduced parasympathetic activity and increased sympathetic activity, is implicated in PCOS and dyslipidemia. Altered autonomic balance can affect lipid metabolism, resulting in increased lipid synthesis and reduced clearance, thereby contributing to dyslipidemia.[11]

Insulin resistance, a common metabolic feature of PCOS, may mediate the relationship between HRV and lipid profile. Insulin resistance has been associated with impaired HRV and dyslipidemia in PCOS. Insulin resistance can directly affect the autonomic nervous system and alter HRV parameters.[12] Additionally, insulin resistance is known to promote dyslipidemia by increasing lipolysis, triglyceride synthesis, and reducing HDL-C levels.

Chronic inflammation and oxidative stress, frequently observed in PCOS, likely contribute to the associations between HRV and lipid profile. These factors influence autonomic function, lipid metabolism, and dyslipidemia by affecting lipid synthesis, transport, and metabolism.[13]

The study's findings have significant clinical implications for managing PCOS and cardiovascular health. Assessing HRV in women with PCOS can help identify those at higher cardiovascular risk.[12] Reduced HRV may serve as an early marker for targeted interventions and lifestyle modifications to enhance lipid profile and cardiovascular well-being.

Furthermore, interventions aimed at improving HRV, such as lifestyle modifications, stress reduction techniques, and physical activity, may have a beneficial impact on the lipid profile in women with PCOS. Targeted interventions addressing autonomic dysfunction and dyslipidemia in PCOS could potentially reduce the risk of cardiovascular events and improve long-term outcomes in this population.[14] Our study findings align with previous research, confirming the consistent associations between HRV and lipid profile in women with PCOS.

In a study by Spruill et al. (2010),[15] HRV was associated with adverse lipid profiles in African American women. These findings align with our study, indicating a consistent relationship between HRV and lipid profile across different populations, including women with PCOS.

Additionally, a study by Jaiswal M et al. (2013),[16] explored the association between HRV and lipid profile in patients with metabolic syndrome. The results demonstrated that decreased HRV parameters were significantly correlated with unfavorable lipid profiles, characterized by elevated total cholesterol, LDL-C, and triglycerides, and decreased HDL-C levels. These findings align with our study, supporting the notion that impaired HRV is associated with dyslipidemia in various metabolic disorders, including PCOS.

Furthermore, a systematic review and meta-analysis conducted by Haensel et al. (2008),[17] assessed the relationship between HRV and dyslipidemia in different populations. The results revealed consistent associations between reduced HRV and adverse lipid profiles, including elevated total cholesterol, LDL-C, and triglycerides, and decreased HDL-C levels.[18] Although this meta-analysis did not specifically focus on PCOS, its findings reinforce the associations observed in our study and highlight the generalizability of these associations across diverse populations.

The consistent associations between HRV and lipid profile in diverse populations, including our study on women with PCOS, support the link between impaired HRV and dyslipidemia. Autonomic dysregulation, insulin resistance, chronic inflammation, and oxidative stress may contribute, but further research is required for a comprehensive understanding.

Limitations

Due to the cross-sectional design, causality between HRV and lipid profile in PCOS cannot be established. Longitudinal studies and interventions are necessary to confirm temporal relationships and assess the impact of HRV-targeted interventions on lipid profile and cardiovascular outcomes. Generalization of findings should be done cautiously due to the specific study population.

CONCLUSION

Our study demonstrates significant associations between heart rate variability (HRV) and lipid profile in women with PCOS, highlighting the clinical importance of HRV assessment. Incorporating HRV assessment in PCOS management can aid in early detection, targeted interventions, and enhanced cardiovascular outcomes. This emphasizes the potential benefits of integrating HRV assessment into the care of individuals with PCOS.

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