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Association of Biological Factors and Polycystic Overy Syndrome

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Abstract
Polycystic Ovarian Syndrome (PCOS) is a common hormonal disorder in women of reproductive age, marked by enlarged ovaries and multiple small follicles. While the exact cause is unknown, genetic, environmental, and lifestyle factors are believed to contribute. Increased androgen levels disrupt normal ovulation, causing irregular periods and fertility issues. Clinically, many of its manifestations arise from elevated androgen levels, which interfere with normal ovarian function, leading to anovulation, irregular menstrual cycles, and reduced fertility. In this article, we present a biological model of PCOS developed using a range of physiological and hormonal factors.

Keywords: - PCOS, Predictive model, Chi-square test, Hormonal condition.

INTRODUCTION

Polycystic Ovarian Syndrome (PCOS) is one of the most common endocrine disorders affecting women of reproductive age. It is characterized by the presence of multiple small, fluid-filled follicles within the ovaries, which gives rise to the term “polycystic.” These follicles contain immature eggs that do not develop sufficiently to trigger ovulation. When ovulation does not occur, it leads to hormonal imbalances involving estrogen, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH). Typically, women with PCOS have lower levels of progesterone and unusually high levels of androgens. This rise in male hormones interferes with the normal menstrual cycle, resulting in fewer or irregular menstrual periods.

The hormonal imbalance caused by PCOS affects several biological processes in a woman’s body. One of the most noticeable impacts is on the menstrual cycle. Many women experience infrequent, delayed, or prolonged menstrual periods. Along with cycle irregularity, a range of physical symptoms can develop. These include excessive hair growth on the face or body (hirsutism), persistent acne, oily skin, and weight gain or obesity. In certain cases, dark patches of skin may appear in body folds such as the neck, armpits, or groin, a condition known as acanthosis nigricans. Women may also experience hair thinning on the scalp, headaches, mood disorders, and the development of some masculine features due to elevated androgen levels.

Beyond the immediate symptoms, PCOS can lead to several long-term complications if not identified and managed early. These complications include infertility due to irregular ovulation, metabolic syndrome, type 2 diabetes, cardiovascular diseases, hypertension, sleep disorders, abnormal uterine

bleeding, and an increased risk of endometrial cancer. Mental health concerns such as anxiety, depression, and disordered eating patterns are also frequently observed in women living with PCOS. These broad-ranging effects highlight the importance of understanding the condition, identifying risk factors, and promoting timely diagnosis and treatment.

Motivation for the Study

While selecting this topic, it became evident that awareness regarding PCOS remains limited. Surprisingly, the lack of knowledge was found not only among men but also among many women who were unfamiliar with the condition despite its growing prevalence. Due to lifestyle changes, stress, environmental exposures, and dietary patterns, PCOS has become increasingly common across the globe. When detected early and treated appropriately, PCOS can be effectively managed, preventing severe complications. However, delayed diagnosis—often caused by unawareness and neglect—can allow the condition to progress into a more severe reproductive and metabolic disorder. This realization motivated us to explore PCOS in detail, study its symptoms, understand its effects on women's health, and analyze the various associated factors using statistical methods.

PCOS in the Indian Context

PCOS has shown a particularly high prevalence in India over the past decade. Recent statistics indicate that nearly one in five Indian women is affected by this condition. Urban women appear to be at a greater risk, primarily due to sedentary lifestyles, unhealthy eating habits, and increased levels of stress. Additionally, obesity plays a major role in the development and severity of PCOS; more than 80% of women diagnosed with PCOS in India are either overweight or obese. Several factors contribute to the rising cases of PCOS among Indian women, including genetic predisposition, insulin resistance, and low-grade chronic inflammation. Understanding these factors is essential to design effective preventive strategies and predictive models.

Objectives of the Study

The major objectives of the study are:

1. To examine the factors affecting the reproductive health of women that may lead to PCOS.
2. To assess the association between different variables and PCOS using the Chi-square test of independence.
3. To identify which variables significantly contribute to the diagnosis of PCOS.

METHODOLOGY

Although PCOS is not always regarded as a severe or widely discussed condition, it is a significant health issue affecting women across the world. In this project, we obtained our data through secondary sources, which helped us conduct a more accurate and detailed analysis. Secondary data refers to information that has been collected previously by individuals, government institutions, or research organizations for purposes other than the present study. Using such data allows researchers to explore trends, associations, and patterns without needing to perform primary data collection, which can be time-consuming and resource-intensive.

The secondary dataset used in this study includes various biological and hormonal parameters relevant to PCOS. Analyzing these parameters provides insights into how different bodily functions are altered in

women with PCOS, and aids in the development of a prediction model that can support future research. The biological terms and their relevance to PCOS are explained below:

Biological Parameters and Their Relevance to PCOS

• BMI – Body Mass Index

BMI is an indicator of body fat based on height and weight. Women diagnosed with PCOS commonly exhibit higher BMI values, often falling into the overweight or obese category.

• RR – Respiratory Rate

Respiratory Rate measures the number of breaths taken per minute. Although not a primary PCOS marker, it contributes to evaluating overall physical health.

• Hb – Hemoglobin

Hemoglobin represents the oxygen-carrying capacity of red blood cells. Its measurement helps assess general health and possible metabolic disturbances.

• Beta-HCG (1 and 2)

Beta-HCG is used to detect pregnancy.

– 1 Beta-HCG indicates pregnancy.

– 2 Beta-HCG indicates non-pregnancy.

These values help confirm whether hormonal fluctuations are related to pregnancy or PCOS.

• FSH – Follicle Stimulating Hormone

FSH regulates the menstrual cycle and stimulates the growth of ovarian follicles. Women with PCOS typically have low or lower-range FSH levels, contributing to impaired follicular development.

• LH – Luteinizing Hormone

LH controls ovulation by triggering the release of a mature egg. Women with PCOS frequently have elevated LH levels, which disrupt ovulation and contribute to anovulation.

• LH/FSH Ratio

A characteristic sign of PCOS is an increased LH-to-FSH ratio, often observed as 2:1 or even 3:1 in many cases.

• TSH – Thyroid Stimulating Hormone

TSH measures thyroid function. Many women with PCOS show slightly elevated TSH levels, indicating a possible link between PCOS and thyroid dysfunction.

• AMH – Anti-Müllerian Hormone

AMH is produced by ovarian follicles and reflects ovarian reserve. Women with PCOS usually have significantly higher AMH levels, which correlate with an increased number of follicles.

• PRL – Prolactin

Prolactin stimulates milk production after childbirth. PCOS patients generally show lower PRL levels, although abnormalities in prolactin can sometimes mimic PCOS symptoms.

• PRG – Progesterone

Progesterone is essential for maintaining the uterine lining and supporting early pregnancy. Women with PCOS often require higher progesterone supplementation because they do not ovulate regularly.

• RBS – Random Blood Sugar

This measures blood glucose levels at any time of the day. PCOS is closely associated with insulin resistance, making women more susceptible to type-2 diabetes.

• BP Systolic and BP Diastolic

Systolic and diastolic blood pressure readings help identify cardiovascular health. Women with PCOS frequently exhibit higher blood pressure, increasing their risk of heart disease.

• Follicle Number (Left and Right Ovary)

Follicle count is often elevated in PCOS patients. Multiple small follicles are present because the eggs do not mature and ovulate properly.

• Average Follicle Size (Left and Right Ovary)

In PCOS, follicles often remain small and do not reach the size needed for ovulation, leading to disrupted menstrual cycles.

• Endometrium Thickness

The endometrium is the lining of the uterus. Its thickness is influenced by hormonal balance, and irregular ovulation in PCOS can lead to abnormal endometrial development.

The mean thickness of the endometrium is statistically higher in the PCOS group.

STATISTICAL ANALYSIS

Exploratory Data Analysis (EDA) serves as the initial and one of the most essential stages of statistical investigation. It involves examining a dataset through numerical summaries, visualizations, and descriptive techniques to uncover underlying patterns, detect anomalies, and understand the structure of the data. EDA allows researchers to observe distributions, identify trends, and study relationships between variables before applying formal statistical methods. Common tools used in EDA include summary statistics such as mean, median, standard deviation, and range for numerical variables. Visual representations—such as bar charts, histograms, boxplots, and pie charts—provide additional insight and help reveal hidden characteristics of the dataset. The primary purpose of EDA is exploration rather than hypothesis confirmation, enabling analysts to gain a comprehensive understanding of the data prior to deeper statistical modelling. The Chi-square (χ^2) test for independence is a statistical hypothesis test used to determine whether two categorical variables are associated or independent of each other. It compares the observed frequencies in a contingency table with the frequencies expected under the assumption that the variables are unrelated. If the difference between observed and expected frequencies is large enough, the test concludes that a significant association exists.

In this study, the Chi-square test is performed using R software, and Yates' continuity correction is applied where appropriate to improve accuracy, particularly for 2×2 contingency tables. The test requires categorical or grouped data; therefore, continuous variables may be categorized into meaningful intervals before analysis. This method helps identify which factors have a potential relationship with PCOS, making it a crucial step in understanding the structure of the dataset. The age distribution shown in Figure 1 highlights the range and concentration of ages among the women included in the study. From the graph, it is evident that the majority of the participants fall within the reproductive age group, typically defined as 15–49 years. This concentration is expected, as PCOS most commonly affects women during their reproductive years due to its direct impact on menstrual cycles, ovulation, and hormonal balance.

The presence of a large proportion of women in this age group indicates that the dataset is appropriately aligned with the target population for studying PCOS. Since the condition is strongly associated with reproductive health issues such as irregular periods, infertility, and hormonal disturbances, having a sample dominated by women of reproductive age enhances the relevance and accuracy of the analysis.

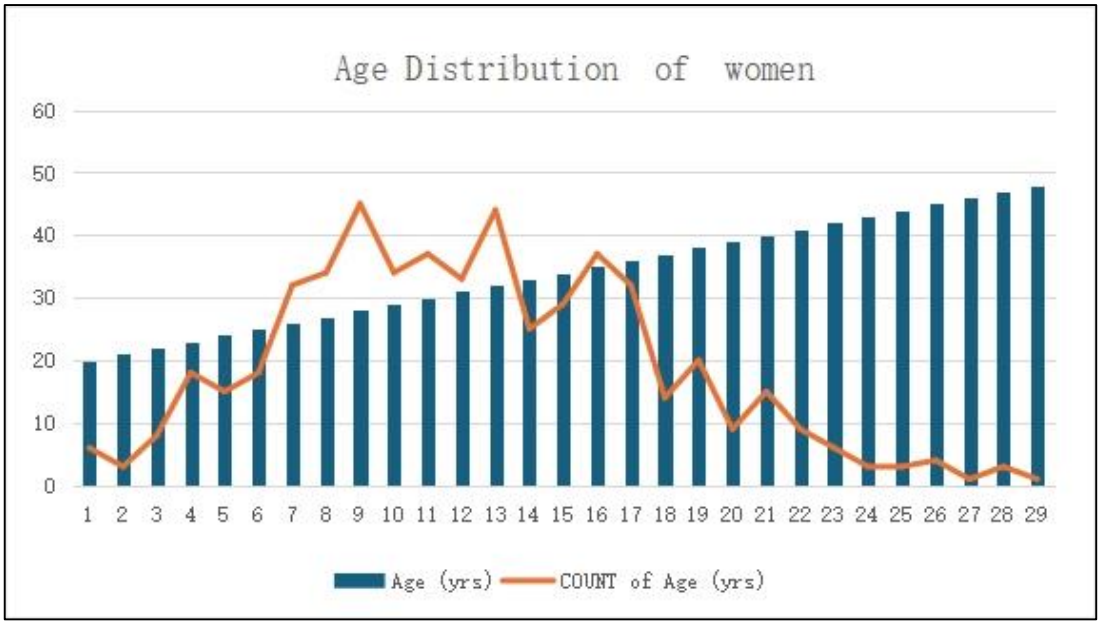

Fig. 1: Age Distribution of women

Furthermore, this age concentration suggests that the dataset captures the group most at risk of developing PCOS-related symptoms and complications. It also supports the validity of subsequent statistical tests and predictive models, as the variables measured (such as hormonal levels, follicle counts, BMI, and metabolic parameters) are particularly meaningful within this age bracket. In summary, the age distribution graph confirms that the sample population is representative of the age group most affected by PCOS, ensuring that the findings of the study are meaningful, applicable, and scientifically reliable.

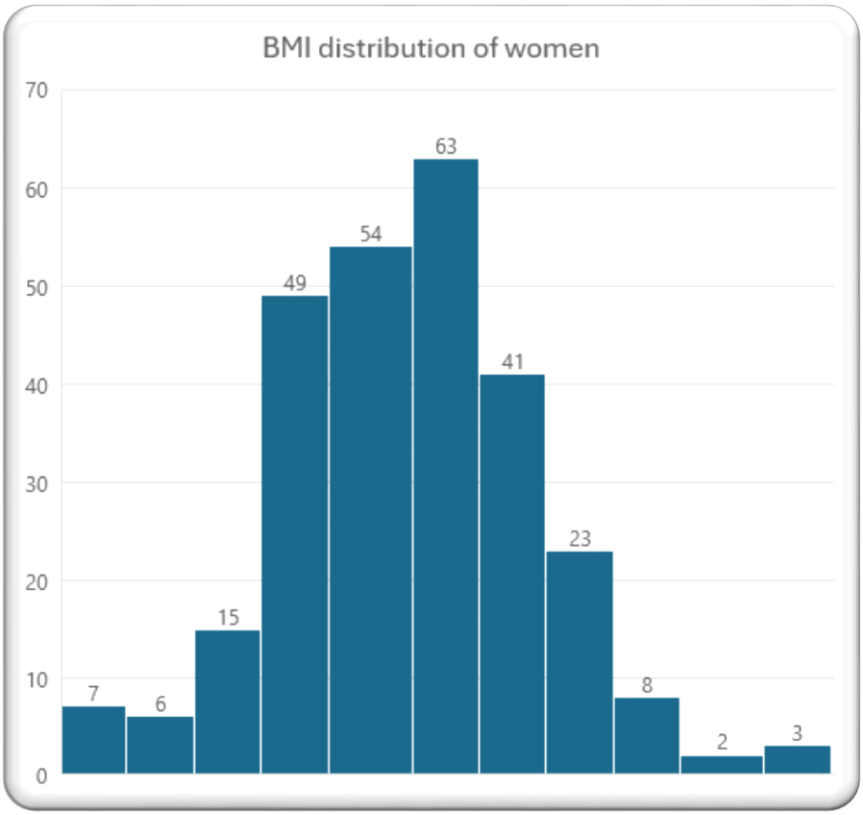

Fig. 2: BMI distribution of women

The BMI (Body Mass Index) distribution graph Fig. 2 shows how the BMI values of women in the dataset are spread across different ranges. The conclusion states that most women have a BMI around 25, which indicates that the highest concentration or peak of the distribution lies near this value. A BMI of around 25 falls at the upper end of the normal range or at the boundary between normal weight and overweight (according to general BMI classifications). The graph Fig.3 shows that weight gain is a common symptom among women with PCOS. Nearly 70% of women diagnosed with PCOS reported experiencing weight gain, indicating a strong link between the condition and metabolic changes. This suggests that hormonal imbalance and insulin resistance, which are common in PCOS, likely contribute to increased body weight in most affected women. The graph Fig. 4 shows a clear relationship between body hair growth and PCOS. Among the women who reported excessive body hair growth, nearly 70% were diagnosed with PCOS. This indicates that abnormal hair growth is a common symptom of the condition, likely caused by hormonal imbalances such as increased androgen levels.

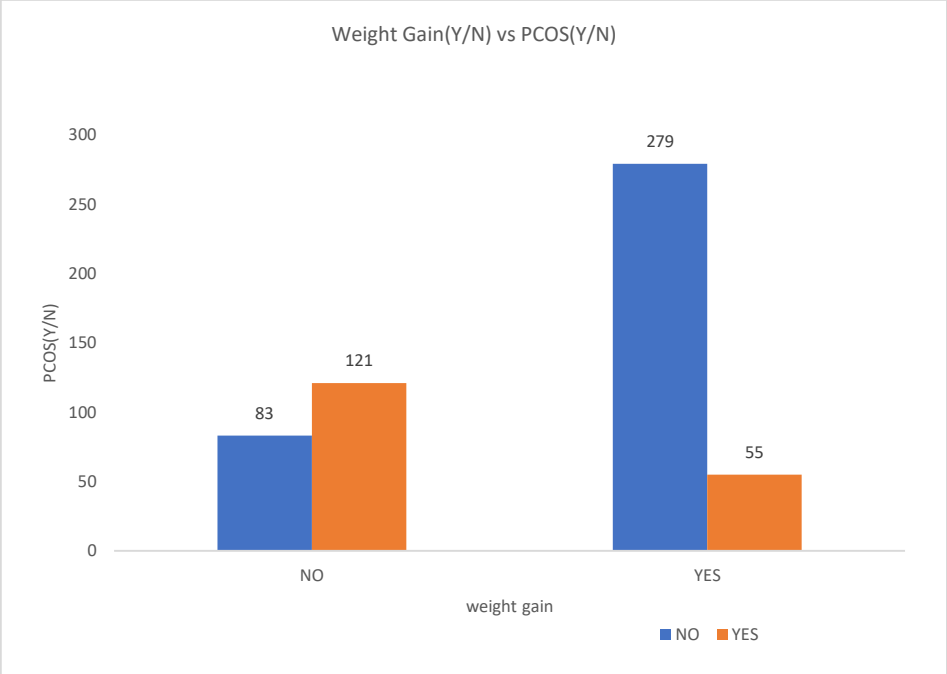

Fig.3 : Weight gain vs PCOS

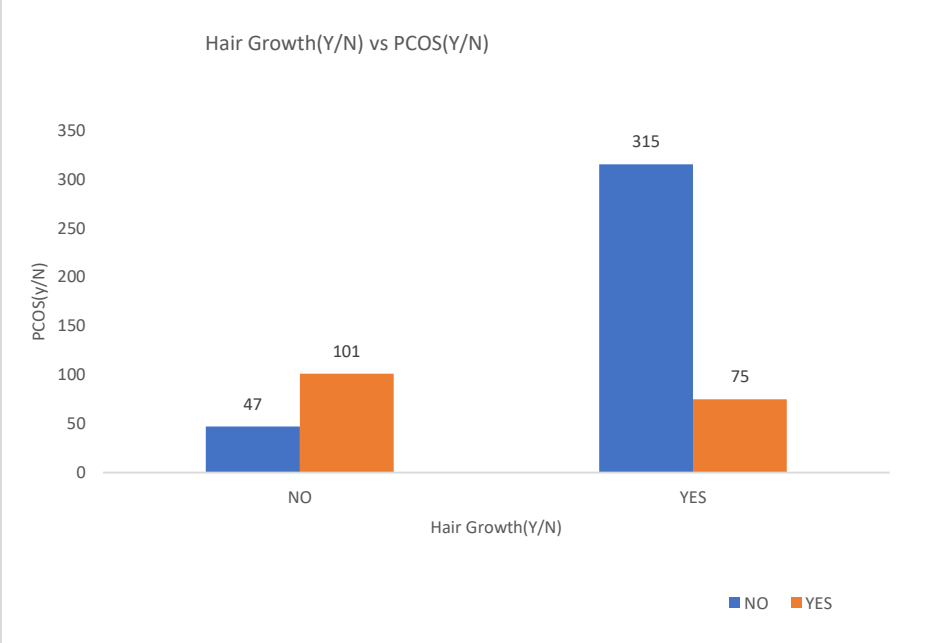

Fig. 4: Hair growth vs PCOS

The graph Fig. 5 indicates that skin darkening is a frequent symptom among women diagnosed with PCOS. More than 60% of women with PCOS reported experiencing skin darkening, suggesting a strong link between the condition and changes in skin pigmentation. This is often associated with insulin resistance, a common feature of PCOS, which can lead to darkened patches of skin, especially around the neck, underarms, and other body folds. The graph Fig. 6 shows that hair loss is a fairly common symptom

among women with PCOS. Over 55% of women diagnosed with PCOS reported experiencing noticeable hair loss. This is typically linked to hormonal imbalances, especially elevated androgen levels, which can weaken hair follicles and lead to thinning or excessive shedding.

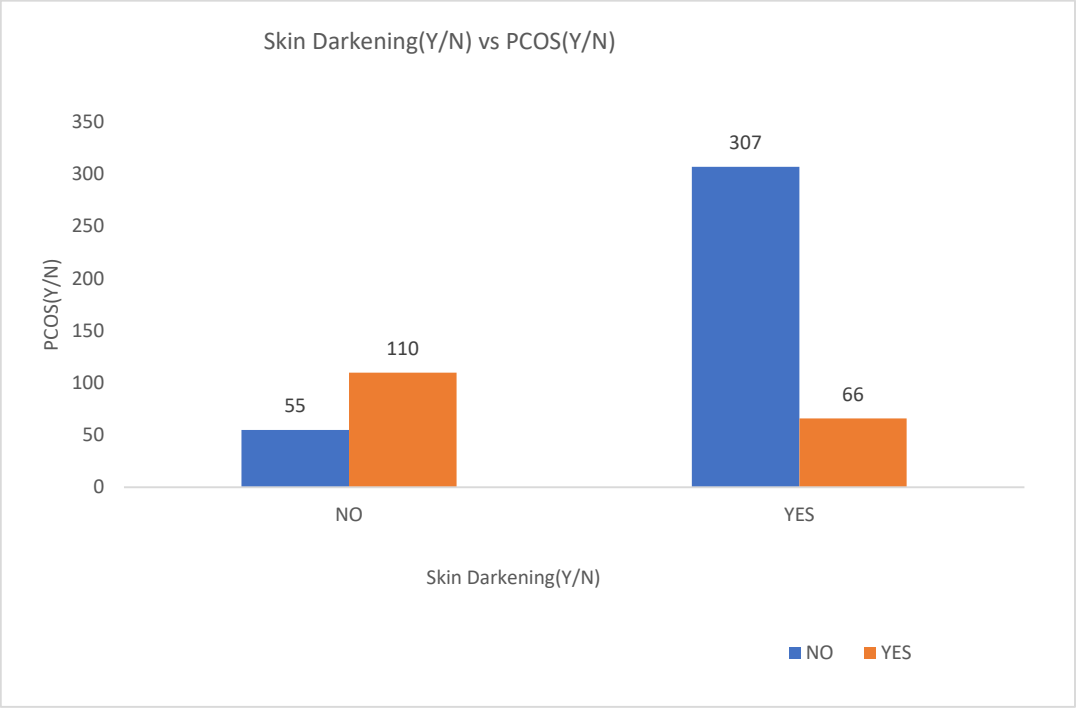

Fig. 5: Skin darkening vs PCOS

The graph Fig. 7 shows that pimples are a common symptom among women with PCOS. Nearly 70% of women diagnosed with PCOS reported having frequent pimples, indicating a strong connection between hormonal imbalance in PCOS and increased acne. This suggests that elevated androgen levels in PCOS often contribute to skin issues like persistent pimples. The graph Fig. 8 shows a mixed relationship between fast-food consumption and PCOS. Among women who consume fast food, half are diagnosed with PCOS and half are not, indicating no direct split within this group. However, when looking specifically at women with PCOS, nearly 80% of them consume fast food. This suggests that while fast-food habits are common in general, they are especially prevalent among women suffering from PCOS, possibly contributing to lifestyle-related risk factors. The graph Fig. 9 shows that lack of regular exercise is common among women with PCOS. Over 70% of women diagnosed with PCOS reported that they do not exercise regularly. This suggests that limited physical activity may be a contributing lifestyle factor associated with PCOS and highlights the importance of regular exercise in managing its symptoms.

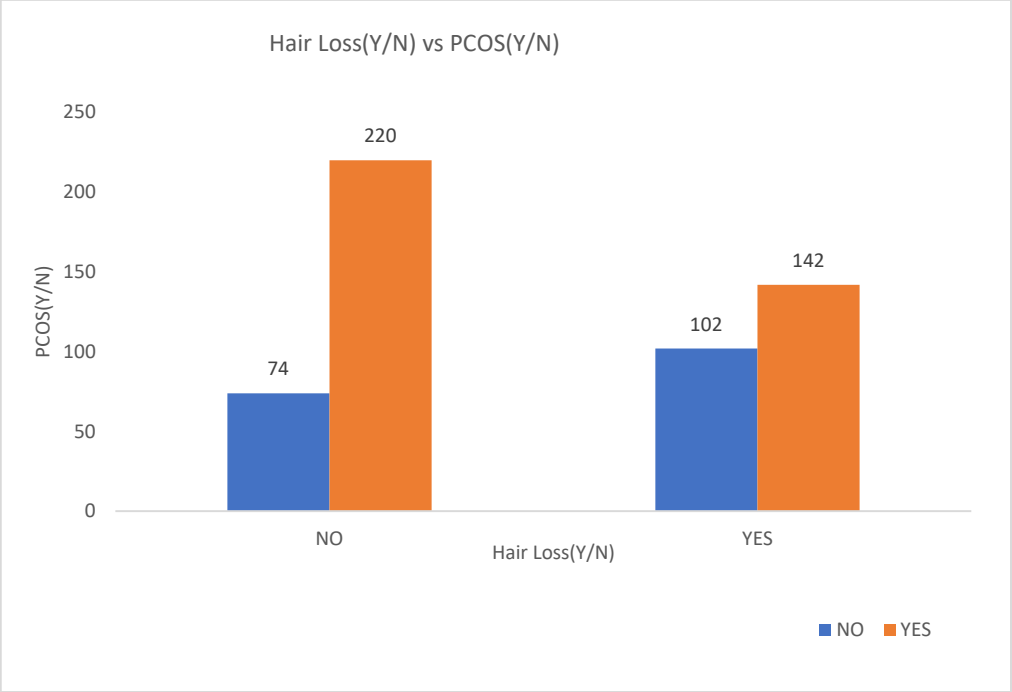

Fig. 6: Hair loss vs PCOS

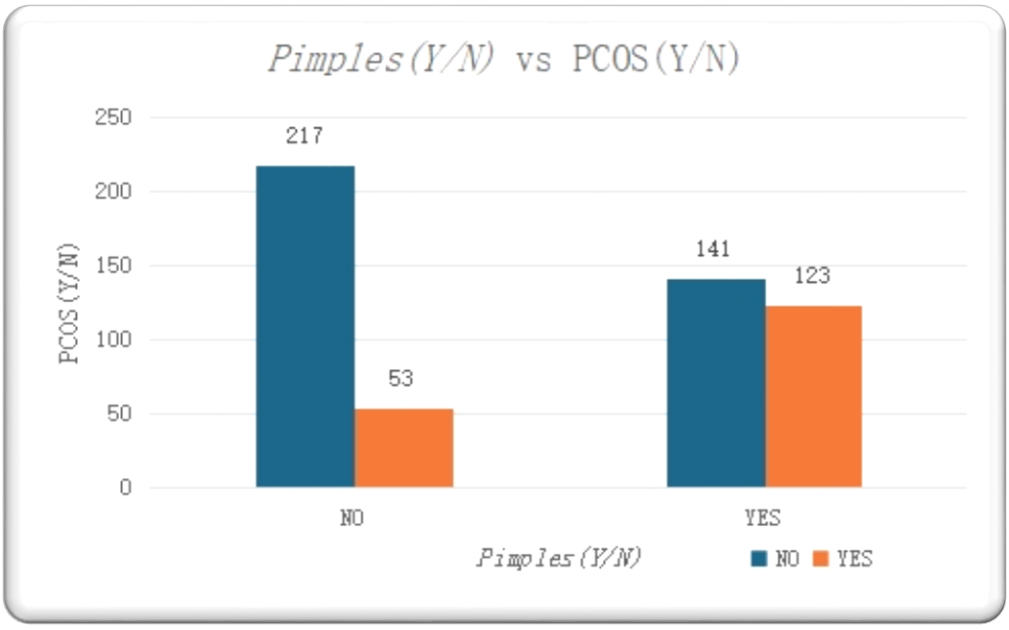

Fig. 7: Pimples vs PCOS

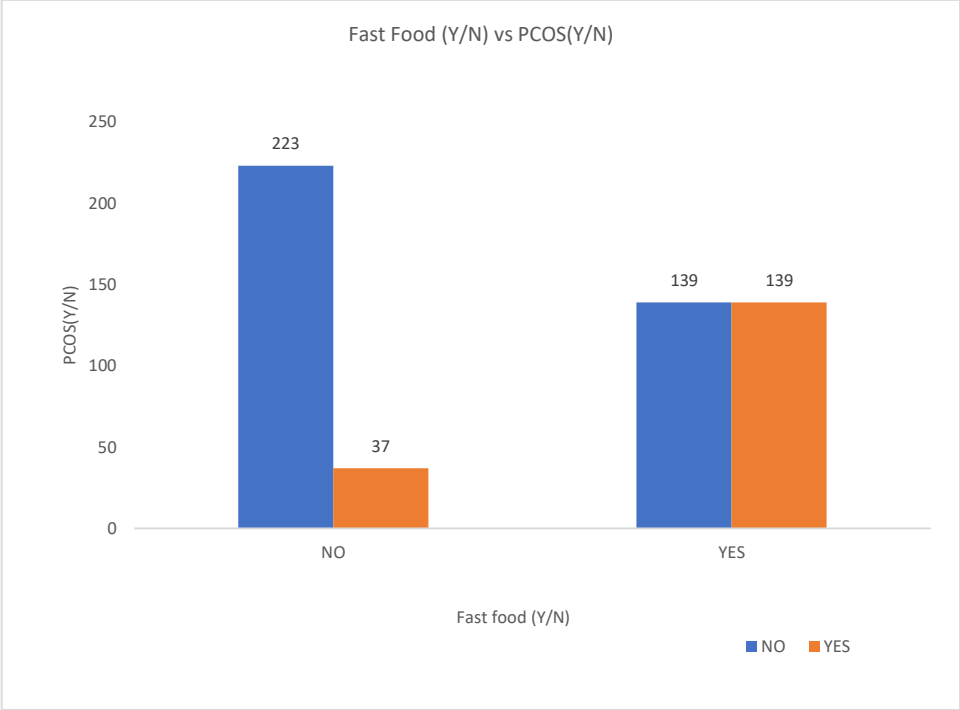

Fig. 8: Fast food vs PCOS

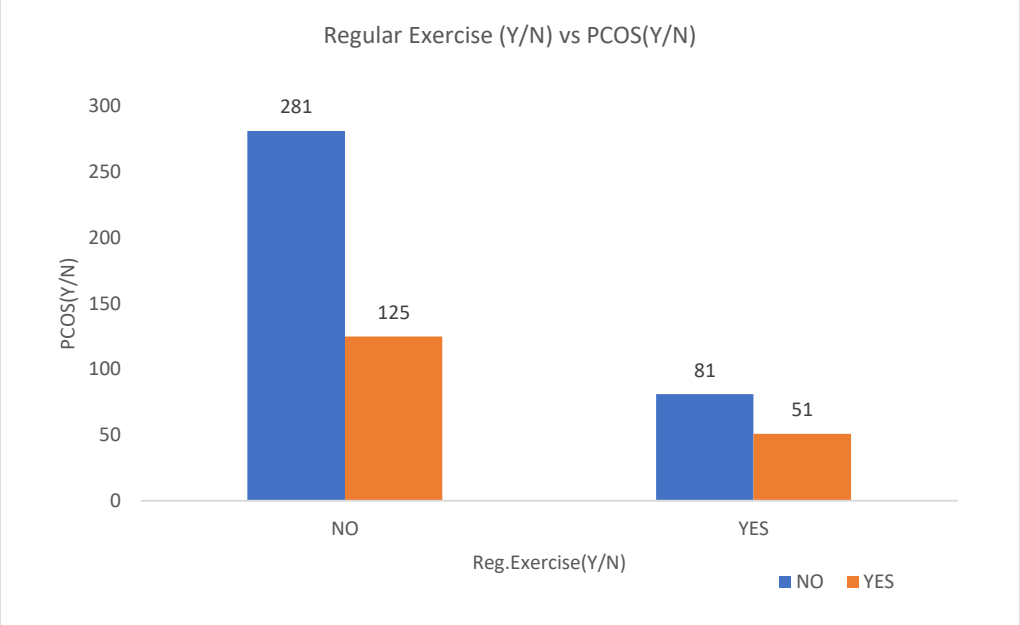

Fig. 9: regular exercise vs PCOS

Chi-square test of Independence PCOS and BMI. To test: H_0: PCOS and BMI are not associated. H_1: PCOS and BMI are associated. Test statistic = 9.5569, p-value=0.0001 < 0.05. Thus, we reject H_0 and we conclude that both are associated attributes.

CONCLUSIONS

PCOS affects women's reproductive health and is influenced by factors such as hormonal levels (LH, AMH, PRG), follicle size, and endometrium thickness, which should be tested when in doubt. Common symptoms: sudden weight gain, abnormal hair growth, skin darkening, hair loss, and pimples: require prompt medical attention. Lifestyle factors like diet and lack of exercise, along with marital status, also play a role. Often, PCOS is detected late when women seek help for conception, making natural treatment harder and sometimes necessitating hormonal therapy with side effects. Early detection allows easier and more natural management, but symptoms are frequently overlooked, highlighting the need for awareness and timely intervention.

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