Volume 3, Issue 2, February 2025 ISSN (E): 2938-3765

# POLYCYSTIC OVARY SYNDROME- BODY MASS INDEX: HORMONAL AND METABOLIC IMPLICATIONS

Afaf Abdul-Hakeem,
MSc. Clinical Biochemistry Student 1.
afaf.a.hakeem@uomustansiriyah.edu.iq

Assistant Professor Dr. Ali Abdulateef Hasan Al-bayati 1 (MD, PhD);
alialbayati_biochem@uomustansiriyah.edu.iq

Assistant Professor Dr. Manal Madany A. Qader 2
F.I.C.M.S., C.A.B.O.C.(OB /GYN),
manalmadany@uomustansiriyah.edu.iq

1 Department of Chemistry and Biochemistry,
College of Medicine, Mustansiriyah University, Iraq
2 Department of Obstetrics & Gynecology / College of Medicine,
Mustansiriyah University / AL-Yarmouk Teaching Hospital, Baghdad, Iraq

**Abstract**

**Background and aim:** Polycystic ovary syndrome (PCOS) is a common endocrine and metabolic disorder affects women in the reproductive age group. PCOS is frequently associated with Obesity. A prominent interplay was noticed between BMI value and hormonal changes accompanying PCOS. The study aims to elucidate role of hormonal factor Anti-Müllerian hormone (AMH) and metabolic factor represented by Myonectin in PCOS patients addressing the effects of BMI on these hormones.

**Patients and methods:** A case-control study was conducted in Baghdad, Iraq. The overall sample size (n = 90) that met the inclusion criteria was divided into two groups as follows: 60 patients who were diagnosed with PCOS and 30 healthy matched women. BMI was calculated using dividing each participants weight in kilograms by their height in meters squared. Blood sample taken for hormonal analysis. Enzyme-linked immunosorbent assay ELISA is used for measuring AMH and Myonectin. Enzyme-linked fluorescence immunoassay (ELFA) used to measure LH and FSH.

**Results**: Body Mass Index (BMI), PCOS patients had significantly higher values than controls (P = 0.002). Anti-Müllerian Hormone (AMH) were notably higher in patients, with a highly significant P value of 0.0001, while myonectin levels were substantially lower in patients compared to controls, with a P value of 0.0001. correlation analysis revealed that AMH levels had a strong negative correlation with Myonectin levels ($r = -0.697$, $p < 0.0001$). AMH has strong positive correlation with LH ($r = 0.618$, $p < 0.0001$). Regarding BMI, a negative correlation



Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

observed with Myonectin and LH, while a positive correlation obtained with AMH ($r = 0.4667$, $p < 0.023$).

**Conclusion**: PCOS and BMI is closely related and interacted. AMH and Myonectin could be used as biomarkers for diagnosis of PCOS and its metabolic changes. Obesity is an important feature observed in PCOS patients and shown to influence variable hormonal changes in those patients.

**Keywords**: Polycystic ovary syndrome; Body Mass Index; Anti-Müllerian hormone; Myonectin.

## Introduction

Polycystic ovary syndrome (PCOS) is a complex endocrine and metabolic disorder that commonly affects women in the reproductive age group. PCOS is firstly described by Stein and Leventhal in 1935.(Deswal et al., 2020) Typically, it is characterized by anovulation, infertility, obesity, insulin resistance, and polycystic ovaries morphology. PCOS is commonly associated with multiple metabolic abnormalities, including insulin resistance (IR), type 2 diabetes mellitus (T2DM), dyslipidemia, and obesity.**(Dar et al., 2024)**

High body mass index, important indicator for obesity, connected with PCOS in complex and multifaceted manner. In general, elevated BMI is strongly associated with hormonal imbalances in PCOS patients. Increased BMI leads to elevated androgen levels that associated worse metabolic profile. (Lazúrová et al., 2019) Furthermore, an observed higher level of Luteinizing Hormone (LH) and higher LH/FSH(follicle stimulating hormone) Ratio in PCOS shown to be unexpectedly negatively correlated with BMI. (Zippl et al., 2021) Moreover, an important characteristic of PCOS is insulin resistance in both obese and non-obese women, a well-known observation of aggravated insulin resistance been with higher BMI.(Zhang et al., 2023)

Both ovarian and extraovarian hormones been studied in PCOS patients. Anti-Müllerian hormone (AMH) is a member of the TGF-β super family synthesizes by theca and granulosa cells of the ovaries. AMH controls the process of ovarian folliculogenesis) (Almeida et al., 2018). In general, increased in AMH production of PCOS compared to normal ovaries. AMH has been demonstrated to block FSH-induced aromatase activity and eliminate the growth-promoting effects of FSH on granulosa cells, resulting in a reduction in the synthesis of estradiol. This imbalance implies that elevated AMH levels most likely contribute to the development of PCOS and anovulation.(Simons et al., 2021)AMH shown to be negatively correlated with BMI on PCOS.(Lefebvre et al., 2017)

Myonectin is a new biomarker secreted by skeletal muscle and regulate many metabolic processes including glucose and lipid metabolism.(Recinella et al., 2020) There is an inverse correlation between myonectin levels and obesity. Exercise raises the expression of myonectin, and studies showed that aerobic training increase serum myonectin and associated with revers obesity biomarkers.(Pourranjbar et al., 2018) Few researches have been done on myonectin' s role in PCOS. Studies showd that lower myonectin is associated with PCOS and also associated with worsening metabolic profile in PCOS.(Demir and Guler, 2020)

The current study aims to in inspect the role of hormonal factor (AMH) and metabolic factor represented by Myonectin in PCOS patients addressing the effects of BMI on these hormones.

Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

## Patients and Methods

A case control study was approved by ethical committee of the College of medicine at al-Mustansiriyah University department of Chemistry &biochemistry in Baghdad, Iraq according to the national and international standard (Declaration of Helsinki). The study included (60) PCOS patients diagnosed with PCOS according to Rotterdam's criteria and (30) age matched control subject. All participant included in the study were recruitment from the Gynecology department of Al-Yarmouk teaching hospital/ Baghdad, Iraq from (November 2023to March 2024). Verbal consents were obtained from all participants. Fasting 5 mL blood obtained, the serum was separated into two portions; the first portion was used for measurements (LH, FSH) by VIDAS is an automated enzyme-linked fluorescence immunoassay (ELFA) test (Biomerieux / USA). The second portion was frozen at -20 °C until it was used for measuring AMH (ELISA kits supplied by USCN (CEA228Hu) Germany Company, and Myonectin ELISA kits for erythroferrone supplied by USCN (SEU540Hu) Germany.

## Statistical Analysis

Data analysis was done by GraphPad Prism 8.0.2 (CA) software and Microsoft excel. The data presented as mean ± SD. The data tested for normality, and the difference between the two independent means was tested using the Student t test when normally distributed and Mann Whitney's test for non-normally distributed data. correlation analysis performed using Pearson's correlation and its t test were used for quantitative variables. Whenever the probability value is ≤0.05, it is considered significant.

## Results

This study involved 60 patients with PCOS and 30 control subjects. The basic characteristics of the two groups are shown in Table 1. Hereby compares key health and biological characteristics between patients (n = 60) and control participants (n = 30), several significant differences were observed. There was no age difference between PCOS patient compared to controls thanks for good age matching. When examining Body Mass Index (BMI), patients had significantly higher values than controls (P = 0.002).

Levels of Anti-Müllerian Hormone (AMH) were notably higher in patients, with a highly significant P value of 0.0001, indicating a substantial difference in this reproductive hormone levels as shown in figure 1. In contrast, in figure 2 myonectin levels were substantially lower in patients compared to controls, with a P value of 0.0001, highlighting a pronounced difference in this muscle-related protein.

The obtained results indicating that AMH levels were significantly higher in PCOS patients than in controls across various BMI categories. These differences proved statistical significance (P values <0.05) (table 2).

The results indicating that Myonectin levels were significantly lower in PCOS patients than in controls across BMI categories. These differences proved statistical significance (P values <0.05) (**table 3**).

To investigate the relationship between study hormones and BMI in polycystic ovarian syndrome, correlation analysis was done for study variables in PCOS patients and controls was shown in table (4). It revealed that **AMH** levels had a strong negative correlation with **Myonectin** levels ($r = -0.697$, $p < 0.0001$). **AMH** has strong positive correlation with **LH** ($r = 0.618$, $p < 0.0001$). Regarding BMI, a negative correlation observed with **Myonectin and LH,** while a positive correlation obtained with **AMH** ($r = 0.4667$, $p < 0.023$).

## Discussion

The relationship between BMI and PCOS is interactive. Raised BMI associated with Aggravated PCOS development and progression, studies showed that significantly increased odds of PCOS as a result of each standard deviation increase in BMI. (Fang et al., 2025, Brower et al., 2019) On the other hand, however PCOS shown to contribute to weight gain, but influential effects of PCOS to statistically increased BMI is less pronounced.(Zhao et al., 2020)

The main results obtained from the current study showed that BMI was significantly higher in PCOS patients compared to controls. Furthermore, AMH levels were significantly higher in PCOS patients than in controls across BMI categories (normal weight, overweight and obese). These differences proved statistical significance (P values <0.05). Simultaneously, Myonectin levels were significantly lower (P values <0.05) in PCOS patients than in controls across BMI categories. Prior studies that have noted the importance of higher AMH as consistent biomarker for diagnosing PCOS as this hormone elevation associated with development of higher number of small antral follicles that typically leads to PCOS morphology.(Tsukui et al., 2022, Qader et al., 2024) The results of the current study confirmed these observations as AMH was significantly higher in PCOS compared to control. Moreover, myonectin as extra-ovarian hormone shown to have impact on metabolism. myonectin levels were substantially lower in PCOS compared to controls, Myonectin have an average for patients (0.461 ng/ml ±0.427) compared to controls (4.090 ng/ml ±1.518). These results are in agreement with those obtained by Demir and Guler (2020). Furthermore, pituitary hormones (LH and FSH) disturbed in PCOS and have impact on its development and progression. The current study showed that significantly higher LH level while FSH shown to significantly lower in PCOS group compared to control. This is consistent with previous results.(Akram, 2015)

The interaction between BMI and hormonal changes in PCOS is substantial, its well known that obesity and increased body weight is associated with endocrine. In the current study, BMI shown to be associated with variable hormones in PCOS patients. BMI is significantly and positively correlated with AMH, which comes in agreement with previous study.(Lefebvre et al., 2017) Furthermore, AMH shown to be significantly different in variable categories of BMI in PCOS compared to controls, while no differences observed in PCOS's BMI subgroups which can be attributed to PCOS phenotypes differences. These results also observed by Gupta, M., et al. (Gupta et al., 2019)

The important observations regarding ovarian hormones are that LH is positively correlated with AMH and negatively correlated with Myonectin and BMI. The changes observed in FSH correlation analysis is not the same. AMH shown to be negatively correlated with FSH, but no observed significant association of FSH with Myonectin and BMI in PCOS patients. These



Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

observations could reveal the fact that LH changes regarded the leading hormone responsible for PCOS morphology and metabolic changes associated with the condition. Conversely, FSH is less likely affected by hormonal changes.

## Conclusion

Poly cystic ovarian syndrome is associated with hormonal and metabolic changes. AMH and Myonectin could be used as biomarkers for diagnosis of PCOS and its metabolic changes. Obesity is an important feature observed in PCOS patients and shown to influence variable hormonal changes in those patients.

## Acknowledgment

The researchers extend their gratitude to the staff of the aforementioned hospital who supported the process of study.

Declaration of patient consent

All patients gave written consent prior to enrollment.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

## References

1. AKRAM, W. 2015. Prediction of insulin sensitivity grade from various demographic, clinical, biochemical and hormonal variables among women with polycystic ovary syndrome. MMJ, 14**,** 1-5.
2. ALMEIDA, F. R., COSTERMANS, N. G., SOEDE, N. M., BUNSCHOTEN, A., KEIJER, J., KEMP, B. & TEERDS, K. 2018. Presence of anti-Müllerian hormone (AMH) during follicular development in the porcine ovary. PLoS One, 13**,** e0197894.
3. BROWER, M., HAI, Y., JONES, M., GUO, X., CHEN, Y.-D., ROTTER, J., KRAUSS, R., LEGRO, R., AZZIZ, R. & GOODARZI, M. 2019. Bidirectional Mendelian randomization to explore the causal relationships between body mass index and polycystic ovary syndrome. Hum Reprod, 34**,** 127-136.
4. DAR, M. A., MAQBOOL, M., QADRIE, Z., ARA, I. & QADIR, A. 2024. Unraveling PCOS: Exploring its causes and diagnostic challenges. Open Health, 5**,** 20230026.
5. DEMIR, I. & GULER, A. 2020. Association of decreased myonectin levels with metabolic and hormonal disturbance in polycystic ovary syndrome. J. Gynaecol. Endocrinol., 36**,** 947-950.
6. DESWAL, R., NARWAL, V., DANG, A. & PUNDIR, C. S. 2020. The prevalence of polycystic ovary syndrome: a brief systematic review. J. Hum. Reprod. Sci., 13**,** 261-271.
7. FANG, Y., LIU, L., YANG, Y., ZHANG, B. & XIE, S. 2025. Causal Association Between BMI and Polycystic Ovarian Syndrome: Bidirectional 2-Sample Mendelian Randomization Study. J. Clin. Endocr., 110**,** 41-47.

8. GUPTA, M., YADAV, R., MAHEY, R., AGRAWAL, A., UPADHYAY, A., MALHOTRA, N. & BHATLA, N. 2019. Correlation of body mass index (BMI), anti-mullerian hormone (AMH), and insulin resistance among different polycystic ovary syndrome (PCOS) phenotypes–a cross-sectional study. J. Gynaecol. Endocrinol., 35**,** 970-973
9. LAZÚROVÁ, I., LAZÚROVÁ, Z., FIGUROVÁ, J., UJHÁZI, S., DRAVECKÁ, I., MAŠLANKOVÁ, J. & MAREKOVÁ, M. 2019. Relationship between steroid hormones and metabolic profile in women with polycystic ovary syndrome. Physiol. Res., 68.
10. LEFEBVRE, T., DUMONT, A., PIGNY, P. & DEWAILLY, D. 2017. Effect of obesity and its related metabolic factors on serum anti-Müllerian hormone concentrations in women with and without polycystic ovaries. Reprod. Biomed. Online, 35**,** 325-330.
11. POURRANJBAR, M., ARABNEJAD, N., NADERIPOUR, K. & RAFIE, F. 2018. Effects of aerobic exercises on serum levels of myonectin and insulin resistance in obese and overweight women. J. Life Med., 11**,** 381.
12. QADER, M. M. A., HUSSEIN, S. S. & JADI, H. F. 2024. Comparison between the levels of anti mullerian hormone after treatment with clomid versus letrozole in polycystic women: an experimental study. JPMA, 74**,** 8.
13. RECINELLA, L., ORLANDO, G., FERRANTE, C., CHIAVAROLI, A., BRUNETTI, L. & LEONE, S. 2020. Adipokines: new potential therapeutic target for obesity and metabolic, rheumatic, and cardiovascular diseases. Front Physiol, 11**,** 578966.
14. SIMONS, P. I., VALKENBURG, O., BONS, J. A., STEHOUWER, C. D. & BROUWERS, M. C. 2021. The relationships of sex hormone-binding globulin, total testosterone, androstenedione and free testosterone with metabolic and reproductive features of polycystic ovary syndrome. Endocrinol Diabetes Metab J 4**,** e00267.
15. TSUKUI, Y., KITAHARA, Y., HASEGAWA, Y., KOBAYASHI, M., OSUKA, S. & IWASE, A. 2022. Anti-Müllerian hormone levels in the diagnosis of adolescent polycystic ovarian syndrome: a systematic review and meta-analysis. Endocr. J., 69**,** 897-906.
16. ZHANG, H., WANG, W., ZHAO, J., JIAO, P., ZENG, L., ZHANG, H., ZHAO, Y., SHI, L., HU, H. & LUO, L. 2023. Relationship between body composition, insulin resistance, and hormonal profiles in women with polycystic ovary syndrome. Front. endocrinol., 13**,** 1085656.
17. ZHAO, Y., XU, Y., WANG, X., XU, L., CHEN, J., GAO, C., WU, C., PAN, D., ZHANG, Q. & ZHOU, J. 2020. Body mass index and polycystic ovary syndrome: a 2-sample bidirectional Mendelian randomization study. J Clin Endocrinol Metab., 105**,** 1778-1784.
18. ZIPPL, A. L., SEEBER, B. & WILDT, L. 2021. Obesity and infertility: Are hyperlipidemia and hyperinsulinemia the bad guys? Fertil Steril 116**,** 365-366.



Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

**Table 1: Basic characteristics of the study population**

| Characteristic | PCOS (n = 60) | Control (n=30) | Total (n = 90) | P value† |
|---|---|---|---|---|
| Age | 28.5±5.7 | 27.3±4.6 | 28.1±5.4 | 0.374 |
| BMI (Kg/m$^2$) | 28.90±5.553 | 25.261±3.622 | 27.74±5.282 | 0.002* |
| **AMH** pg/ml | 3.524±0.780 | 1.283±0.667 | 2.811±1.286 | 0.0001** |
| **Myonectin** ng/ml | 0.461±0.427 | 4.090±1.518 | 1.616±1.931 | 0.0001** |
| **LH**-m. IU/ml | 9.060±2.060 | 5.317±1.419 | 7.869±2.565 | 0.0001* |
| **FSH**-m. IU/ml | 4.770±1.012 | 5.635±1.223 | 5.045±1.150 | 0.001* |

**†Student t-test or Mann Whitney's test**

***Significant at 0.05 level**

**Table 2: AMH in relation to BMI in PCOs and control groups**

| Characteristic | | Patients (n =60) | Control (n=30) | Total (n = 90) | P value† |
|---|---|---|---|---|---|
| **BMI** | **Normal** | **3.259± 0.466** | **1.193± 0.511** | **2.341± 1.149** | 0.0001* |
| | **Overweight** | **3.636± 0.923** | **1.371± 0.829** | **2.755± 1.421** | 0.0001* |
| | **Obese** | **3.590± 0.786** | **1.210± 0.028** | **3.400± 1.000** | 0.0001* |

**†Student t-test or Mann Whitney's test**

***Significant at 0.05 level**

**Table 3: Myonectin in relation to BMI in PCOS and control group**

| Characteristic | | PCOS (n = 60) | Control (n=30) | Total (n = 90) | P value† |
|---|---|---|---|---|---|
| **BMI** | **Normal** | **0.383± 0.201** | **4.420± 1.904** | **2.177± 2.395** | **0.0001*** |
| | **Overweight** | **0.631± 0.632** | **4.061± 1.021** | **1.965± 1.872** | **0.0001*** |
| | **Obese** | **0.350± 0.187** | **2.315± 1.096** | **0.507± 0.615** | **0.0001*** |

**†Student t-test or Mann Whitney's test**

***Significant at 0.05 level**

**Table 4: Correlation of BMI, AMH and Myonectin to ovarian hormones of PCOS patients.**

| | | AMH | Myonectin | BMI |
|---|---|---|---|---|
| **Myonectin** | r | -0.697* | 1.000 | -0.3627* |
| | P value | 0.0001 | | 0.043 |
| **AMH** | r | 1.000 | -0.697* | 0.4667* |
| | P value | | 0.0001 | 0.023 |
| **BMI** | r | 0.4667* | -0.3627* | 1.000 |
| | P value | 0.023 | 0.043 | |
| **LH** | r | 0.618* | -0.627* | -0.351 |
| | P value | 0.0001 | 0.0001 | 0.035 |
| **FSH** | r | -0.299* | 0.256 | -0.187 |
| | P value | 0.005 | 0.066 | 0.155 |



Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

**Figure legends**

**Figure 1: A comparison of AMH between PCOS patients and controls, red bar for PCOS, blue bar for controls, P value significance =0.0001.**

**Figure 2: A comparison of Myonectin-between PCOS patients and controls, red bar for PCOS, blue bar for controls, P value significance =0.0001.**



Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5