Obesity, Endocrine Dysfunction, and PCOS in Adolescence: Clinical Challenges and Management– the role of Artificial Intelligence

Ilta Bylykbashi [1*]

[1] University of Medicine, Tirana; Tirana, Albania

Abstract

Adolescent obesity has become a critical global health concern with significant endocrine and reproductive consequences. Excess adiposity during puberty alters metabolic and hormonal regulation, leading to menstrual dysfunction, insulin resistance, and increased prevalence of polycystic ovary syndrome (PCOS). Diagnosis of PCOS in adolescence remains challenging due to overlap between physiological pubertal changes and pathological features, increasing the risk of both over diagnosis and delayed treatment. Evidence-based management emphasizes lifestyle intervention as first-line therapy, with pharmacologic and emerging adjunctive therapies applied when necessary. This paper reviews mechanisms linking obesity to endocrine dysfunction in adolescence, clinical challenges in PCOS diagnosis, current management strategies, and long-term health implications. A multidisciplinary and patient-centered approach is essential to optimize outcomes and prevent future metabolic and reproductive complications. AI represents a significant advancement for identifying, monitoring, and treating complex, interconnected metabolic and endocrine conditions in adolescents.

This article was conducted as a narrative literature review.

Keywords: adolescent obesity, endocrine dysfunction, menstrual disorders, PCOS, insulin resistance, lifestyle intervention, artificial intelligence.

Address for correspondence: Ilta Bylykbashi *, University of Medicine, Tirana; Tirana, Albania. E-mail: ilta.bylykbashi@yahoo.com

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence:
Clinical Challenges and Management– the role of Artificial Intelligence

2

INTRODUCTION

Obesity during adolescence has risen dramatically worldwide and represents a major public health challenge. In adolescent girls, obesity influences both metabolic and reproductive health, placing adolescent gynecology at the intersection of pediatrics, endocrinology, and reproductive medicine. According to World Health Organization (WHO, 2025), worldwide adult obesity has more than doubled since 1990, and adolescent obesity has quadrupled. In 2022, 2.5 billion adults (18 years and older) were overweight. Of these, 890 million were living with obesity. In 2022, 43% of adults aged 18 years and over were overweight and 16% were living with obesity. In 2024, 35 million children under the age of 5 were overweight. Over 390 million children and adolescents aged 5–19 years were overweight in 2022, including 160 million who were living with obesity (1).

Excess adipose tissue contributes to insulin resistance, altered steroid metabolism, menstrual disturbances, and increased cardiovascular risk. Psychological distress and social stigma further compound health outcomes. Importantly, obesity in adolescence predicts adverse adult health conditions, including type 2 diabetes, infertility, and cardiovascular disease. Early intervention is therefore critical to prevent lifelong complications. Authors like Ullah, M. I., & Tamanna, S. (2025) explores the complex nature of obesity, covering its underlying biology, social and economic consequences, related health conditions, and evolving treatment options (2,3,4,5).

Recent evidence highlights that polycystic ovary syndrome is a heterogeneous endocrine disorder with evolving diagnostic criteria, particularly in adolescents, where hormonal fluctuations and pubertal changes complicate accurate diagnosis and require careful clinical interpretation (6,7). Our aim is to focus on clinical challenges and management of obesity, endocrine dysfunction, and PCOS in adolescence. This due the fact the overweigh and obesity is highly prevalent in Albanian adolescents. Complications can be avoided with early detection of adolescent PCO and endocrine dysfunction. Early diagnosis and treatment facilitate the easy and successful stabilization of the condition for a longer duration (8,9)

Lifestyle interventions, including dietary modification, regular physical activity, and behavioral support, are considered first-line therapy in the management of polycystic ovary syndrome, demonstrating significant benefits on metabolic, hormonal, and reproductive outcomes (10,11).

Current evidence highlights the importance of age-specific diagnostic criteria, tailored management strategies for adolescents with obesity, and recognition of the increasing global burden of polycystic ovary syndrome and its impact on health systems worldwide (12,13).

Integrating artificial intelligence (AI) prospected in the practical clinical management of obesity,

3

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence:
Clinical Challenges and Management– the role of Artificial Intelligence

endocrine dysfunction, and PCOS in adolescence promised significant improvement in efficiency, interpretability, and generalizability. Many studies have highlighted how AI-driven systems can enhance clinical decision-making by combining human expertise with advanced computational models to improve diagnostic accuracy and personalized care (14,15).

Many authors analyses the principal applications of AI those problems management, focusing on prediction, diagnosis, classification, and screening. Several authors analyze the application of machine learning and deep learning techniques in PCOS and endocrine disorder management, demonstrating their value in the analysis of hormonal profiles, imaging data, and electronic health records to support early detection and risk stratification (16,17).

Furthermore, they are focusing in digital health technologies to forge an AI-augmented digital healthcare ecosystem encompassing the prevention and holistic management of those problems. Recent evidence emphasizes the role of big data analytics and digital health platforms in optimizing healthcare resource allocation and supporting long-term, personalized management strategies for obesity-related endocrine conditions (18).

We also discuss strategic avenues that may facilitate the clinical translation of these innovative systems. However, successful clinical translation requires addressing ethical considerations, data governance, and privacy protection, particularly in adolescent populations, where sensitive health data must be managed responsibly and transparently (19,20).

MATERIALS AND METHODS

This study was conducted as a narrative literature review. Relevant peer-reviewed articles, clinical reviews, and guidelines addressing adolescent obesity, endocrine dysfunction, polycystic ovary syndrome, and the application of artificial intelligence in healthcare were identified through structured searches of major biomedical databases. The literature was analysed qualitatively to synthesise current evidence on mechanisms, diagnostic challenges, management strategies, and emerging digital health approaches relevant to adolescent populations.

OBESITY AND ENDOCRINE DYSFUNCTION IN ADOLESCENCE
Metabolic and Hormonal Alterations

Adolescent obesity triggers significant endocrine dysfunction and metabolic alterations, characterized by insulin resistance, chronic inflammation, and hypothalamic-pituitary-gonadal axis disruption. Key hormonal changes include decreased growth hormone, altered thyroid function (TSH), increased cortisol, and leptin resistance, often causing accelerated puberty in girls, delayed puberty in boys, and polycystic ovarian syndrome (PCOS) (2,3).

Adipose tissue acts as an endocrine organ, secreting adipokines and inflammatory mediators that impair insulin signaling. Insulin resistance, common in obese adolescents, promotes

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence:
Clinical Challenges and Management– the role of Artificial Intelligence

4

hyperinsulinemia, which stimulates ovarian androgen production and disrupts ovulation (4,5). Adipose tissue also expresses aromatase, converting androgens to estrogens, leading to peripheral hyperestrogenism. This hormonal imbalance may influence pubertal timing and menstrual regulation (6,7).

Menstrual and Pubertal Consequences

Overweight and obese adolescents face higher risks of gynecologic and obstetric complications both during adolescence and later in life. During adolescence, obesity is linked to multiple gynecological disturbances, including

- Menstrual irregularities often caused by anovulation,
- Excessive menstrual bleeding associated with endometrial thickening,
- A higher frequency of premenstrual symptoms,
- Dysmenorrhea, observed in both underweight and overweight adolescents,
- Engagement in high-risk sexual behaviors.

Weight reduction frequently improves menstrual regularity and hormonal balance, underscoring the role of metabolic control in reproductive health (7).

PCOS IN ADOLESCENCE

Pathophysiology

Polycystic ovary syndrome (PCOS) is a prevalent and multifaceted hormonal disorder, affecting approximately 3–11% of adolescent girls. PCOS is commonly accompanied by obesity and metabolic disturbances (8).

Obesity worsens insulin resistance and stimulates ovarian androgen production, contributing to a range of clinical manifestations in adolescents. These include hyperandrogenism, chronic anovulation, and menstrual irregularities, as well as dermatologic features such as acne and hirsutism. Beyond the physical symptoms, affected adolescents often experience psychological distress, including anxiety, depression, and body-image concerns, highlighting the multifaceted impact of obesity on reproductive and mental health .

However, physiological puberty can mimic PCOS features, complicating diagnosis. Prompt diagnosis and early lifestyle interventions are essential to control symptoms and lower the risk of long-term complications such as type 2 diabetes (9).

Diagnostic Challenges

Polycystic ovary syndrome (PCOS) is a prevalent endocrine and metabolic disorder that often begins around puberty. The 2023 international evidence-based guidelines have refined the diagnostic criteria for adolescents, aiming to reduce controversies and challenges associated with diagnosing PCOS during this sensitive developmental period. This narrative review focuses on the most recent evidence regarding the diagnosis of PCOS in adolescence.

Diagnosing PCOS in adolescents requires particular caution because many features of

normal pubertal development, such as irregular menstrual cycles, acne, and multifollicular ovarian morphology, can mimic the disorder. Current clinical guidelines recommend considering PCOS in adolescents when menstrual irregularity persists beyond the expected pubertal transition and is accompanied by evidence of hyperandrogenism, either clinically (e.g., hirsutism, severe acne) or biochemically (elevated androgen levels). Importantly, a thorough evaluation must exclude other conditions that can cause similar features, including thyroid dysfunction, hyperprolactinemia, nonclassic congenital adrenal hyperplasia, and androgen-secreting tumors. Additional factors such as rapid weight gain, insulin resistance, and family history of metabolic or reproductive disorders can support the diagnosis and guide early intervention. Careful assessment is essential not only to avoid overdiagnosis but also to enable timely lifestyle and medical management, which can reduce long-term reproductive, metabolic, and psychological complications.

The diagnosis should be made with caution, often requiring longitudinal, or long-term, monitoring of symptoms to distinguish them from normal puberty. Pelvic ultrasound is often avoided early after menarche due to high prevalence of physiological ovarian cysts, which may lead to overdiagnosis (10,11).

CLINICAL MANAGEMENT STRATEGIES

Polycystic ovarian syndrome (PCOS) is commonly associated with obesity and has cardio-metabolic, reproductive, and psychiatric comorbidities. PCOS in adolescents is challenging to diagnose. Appropriate screening for PCOS among adolescents with overweight/obesity is essential for timely diagnosis and management.

Lifestyle Intervention

Lifestyle modification remains the cornerstone of therapy for adolescents with PCOS, addressing both metabolic and reproductive aspects of the disorder. A calorie-controlled, nutritionally balanced diet helps manage weight, improve insulin sensitivity, and regulate menstrual cycles. Regular physical activity, at least 60 minutes of moderate-to-vigorous exercise daily, supports cardiovascular health, enhances glucose metabolism, and promotes fat loss, while muscle-strengthening exercises several times per week further improve insulin sensitivity and maintain lean body mass.

Behavioral and psychological support is equally important, as it helps adolescents develop sustainable healthy habits, cope with emotional stress, and address body-image concerns, which are often heightened in the context of obesity or hyperandrogenism. Together, these interventions form a comprehensive strategy that targets the

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence:
Clinical Challenges and Management– the role of Artificial Intelligence

6

underlying metabolic disturbances of PCOS and reduces the risk of long-term complications such as type 2 diabetes, cardiovascular disease, and reproductive dysfunction. Lifestyle modifications not only improve the biochemical, hormonal, and anthropometric parameters in PCOS patients but also reduce the long-term risks of metabolic and cardiovascular diseases.

Weight reduction improves insulin sensitivity, menstrual regularity, and androgen excess while supporting mental health. Behavioral and education modules can also be used to improve awareness, adherence, and the effectiveness of conventional treatment and to manage mental health issues related to PCOS and Endocrine Dysfunction (10).

Pharmacological Treatment and Adjunctive Therapies

Medication is considered for adolescents with PCOS when lifestyle interventions alone are insufficient to control symptoms or address metabolic risk. Combined oral contraceptives (COCs) are commonly used to regulate menstrual cycles, reduce androgen levels, and alleviate symptoms such as acne and hirsutism. Metformin, an insulin-sensitizing agent, can improve insulin resistance, support weight management, and in some cases restore ovulatory cycles, particularly in adolescents with metabolic disturbances. For persistent hyperandrogenic symptoms, antiandrogens such as spironolactone may be prescribed under careful clinical monitoring, taking into account potential side effects and the need for contraception due to teratogenic risk.

Treatment should be individualized based on the patient's symptom profile, metabolic risk factors, reproductive goals, and personal preferences. In addition to established therapies, several adjunctive options are under investigation. Inositols and N-acetylcysteine have shown potential in improving insulin sensitivity, while carnitine supplementation may support metabolic function. Correcting vitamin D deficiency may provide additional benefits, and novel neuroendocrine modulators are currently in early clinical evaluation. While these emerging therapies are promising, further research is needed to establish their long-term safety and efficacy in adolescents with PCOS (11).

LONG-TERM HEALTH IMPLICATIONS

Untreated adolescent obesity and PCOS are associated with significant long-term health risks. These include infertility and pregnancy-related complications, gestational diabetes, and hypertensive disorders, as well as an increased likelihood of developing type 2 diabetes and cardiovascular disease later in life. Additionally, affected individuals face a higher risk of endometrial and other obesity-related cancers, alongside persistent psychological distress such as anxiety, depression, and reduced quality of life.

These potential complications highlight the importance of early identification, timely intervention, and long-term follow-up to monitor

metabolic, reproductive, and mental health outcomes, ensuring that adolescents receive comprehensive care to mitigate both immediate and future health risks (12).

MULTIDISCIPLINARY CARE APPROACH

Optimal management of adolescents with obesity and PCOS requires a coordinated, multidisciplinary approach to address the complex interplay of metabolic, reproductive, and psychological health.

- Pediatricians play a central role in growth monitoring, early identification of obesity, and coordination of care.
- Gynecologists assess menstrual irregularities, hyperandrogenic symptoms, and reproductive risks, while endocrinologists focus on metabolic complications such as insulin resistance, glucose intolerance, and hormonal regulation.
- Nutrition specialists provide individualized dietary guidance to support weight management and improve metabolic outcomes, and exercise or lifestyle counselors design tailored physical activity programs to enhance fitness, insulin sensitivity, and overall health.
- Mental health professionals address psychological challenges common in this population, including anxiety, depression, body-image concerns, and adherence barriers.

By integrating expertise from these disciplines, care can be personalized and holistic, ensuring that both immediate symptoms and long-term risks are effectively managed, while empowering adolescents and their families to adopt sustainable lifestyle and health behaviors (13).

THE ROLE OF AI IN ADOLESCENT OBESITY, ENDOCRINE DYSFUNCTION AND PCOS

Artificial intelligence (AI) has emerging potential in the management of adolescent obesity, endocrine dysfunction, and PCOS, offering tools to enhance diagnosis, risk stratification, and personalized treatment. Machine learning algorithms can analyze large datasets from electronic health records, wearable devices, and biochemical profiles to identify early patterns of metabolic and hormonal dysregulation, enabling timely interventions (14,15). AI-driven predictive models may help assess the risk of insulin resistance, menstrual irregularities, and long-term complications such as type 2 diabetes or cardiovascular disease, facilitating individualized monitoring strategies.

In clinical practice, AI can support decision-making by recommending tailored lifestyle, pharmacologic, or behavioral interventions based on patient-specific data. Additionally, AI-powered digital health applications can engage adolescents in self-monitoring, adherence tracking, and lifestyle coaching, while providing clinicians with actionable insights (16,17).

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence: Clinical Challenges and Management– the role of Artificial Intelligence

8

Despite its promise, the integration of AI in adolescent endocrine care must account for data privacy, ethical considerations, and validation across diverse populations (18). When implemented thoughtfully, AI can enhance early detection, optimize multidisciplinary management, and improve long-term outcomes in adolescents with obesity and PCOS (18).

The integration of artificial intelligence in healthcare raises important ethical and privacy concerns, particularly regarding data protection, transparency, and responsible use of patient information, underscoring the need for robust ethical frameworks and governance mechanisms to ensure safe and equitable implementation (19,20).

Key Aspects of AI in Adolescent Endocrine dysfunction and PCOS

- Early Diagnosis & Risk Prediction: AI algorithms analyze hormonal data and metabolic markers to predict PCOS and metabolic dysfunction even before symptoms fully manifest, which is crucial given that puberty is characterized by normal increases in insulin resistance.

- Management & Treatment: Machine learning models help personalize metabolic management, particularly for polycystic ovary syndrome (PCOS).

- Data Analysis: AI tools analyze ultrasound images and comprehensive datasets to assist in diagnosing polycystic ovary syndrome (PCOS) with high accuracy.

- Tools: AI is integrated with wearables to monitor lifestyle factors, while NLP (Natural Language Processing) assists in reviewing patient records to track weight-related concerns and dietary patterns .

Clinical Challenges & Considerations

- Complexity of PCOS in Adolescence: Diagnosing PCOS is challenging in adolescents due to overlapping symptoms with normal puberty (e.g., irregular cycles, acne), requiring precise, data-driven differentiation.

- Obesity and Metabolic Impact: While obesity is not a defining feature, it drives insulin resistance, worsening the metabolic and reproductive features of PCOS in adolescents.

- Data and Ethical Limitations: AI applications face challenges regarding data quality, algorithmic bias, and privacy.

- Need for Personalization: Despite AI advancements, managing obesity remains challenging as patients often have varied responses to treatments like metformin.

Management Strategies

- Metformin Use: Insulin-sensitizing drugs like metformin are used to improve insulin sensitivity and regulate menstrual cycles.
- Weight Management: AI-powered, personalized, and efficient care plans are used to manage obesity and its metabolic consequences.
- Continuous Monitoring: AI facilitates continuous, data-driven monitoring of metabolic health to prevent further complications like type 2 diabetes or cardiovascular disease.

AI represents a significant advancement for identifying, monitoring, and treating complex, interconnected metabolic and endocrine conditions in adolescents (16,17).

CONCLUSION

Childhood obesity poses a complex threat to endocrine health, driving insulin resistance, thyroid dysfunction, hormonal imbalances, and altered reproductive development. These interlinked disturbances demand early, targeted interventions. Addressing both metabolic and hormonal aspects through comprehensive prevention and treatment strategies is essential to reduce the risk of chronic diseases. A deep understanding of these pathways is crucial for effective clinical care and public health policy for this vulnerable population.

Obesity-driven endocrine dysfunction significantly affects adolescent reproductive health, with PCOS representing a major clinical challenge. Accurate diagnosis, prevention of overmedicalization, and individualized treatment strategies are essential. Lifestyle intervention remains the foundation of management, complemented by pharmacologic therapy when required. A multidisciplinary, patient-centered approach offers the best opportunity to improve immediate symptoms and prevent long-term metabolic and reproductive complications.

AI represents a significant advancement for identifying, monitoring, and treating complex, interconnected metabolic and endocrine conditions in adolescents. Artificial Intelligence in adolescent obesity, endocrine dysfunction, and PCOS enables early diagnosis, personalized treatment, and improved risk prediction by analyzing complex data like hormonal levels (e.g., testosterone, LH), insulin resistance, and imaging. AI models (Machine Learning, Deep Learning, etc) optimize management by identifying metabolic risk, monitoring lifestyle factors via wearables, and predicting disease progression.

Conflict of Interest Statement: The authors declare that they have no conflict of interest.

Bylykbashi, I., Obesity, Endocrine Dysfunction, and PCOS in Adolescence:
Clinical Challenges and Management– the role of Artificial Intelligence

10

REFERENCES

1. World Health Organization. Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

2. Ullah MI, Tamanna S. Obesity: Clinical Impact, Pathophysiology, Complications, and Modern Innovations in Therapeutic Strategies. Medicines 2025; 12(3), 19. https://doi.org/10.3390/medicines12030019

3. Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. International journal of obesity (2005), 35(7), 891–898. https://doi.org/10.1038/ijo.2010.222.

4. Badr M, El-Rabaa G, Freiha M, Kędzia A, Niechciał E. Endocrine consequences of childhood obesity: A narrative review. Frontiers in Endocrinology 2025;, 16, 1584861. https://doi.org/10.3389/fendo.2025.1584861.

5. Prosperi S, Chiarelli F. Insulin resistance, metabolic syndrome and polycystic ovaries: an intriguing conundrum. Frontiers in endocrinology 2025; 16, 1669716. https://doi.org/10.3389/fendo.2025.1669716.

6. Ghafari A, Maftoohi M, Eslami Samarin M, Barani S, Banimohammad M, Samie R. The last update on polycystic ovary syndrome (PCOS), diagnosis criteria, and novel treatment. Endocrine and Metabolic Science 2025; 17, 100228. https://doi.org/10.1016/j.endmts.2025.100228.

7. Bera A, Bagchi B et al. Revisiting Hormonal profile in PCOS in Adolescents and Young Women. Medical Research Archives 2025;[online] 13(4). https://doi.org/10.18103/mra.v13i4.6430.

8. Zhang Y, Yang K, Fan T, Zheng D, Liu H. Diagnosis and Treatment of Adolescent Polycystic Ovary syndrome: A Review. International journal of women's health 2025;17, 459–474. https://doi.org/10.2147/IJWH.S506498.

9. Dokras A. Polycystic ovary syndrome in 2025—insights and innovations. Fertility and Sterility 2025;124(5, Part 2), 907–909. https://doi.org/10.1016/j.fertnstert.2025.09.025.

10. Gautam R, Maan P, Jyoti A, Kumar A, Malhotra N, Arora T. The role of lifestyle interventions in PCOS management: A systematic review. Nutrients 2025;17(2), 310. https://doi.org/10.3390/nu17020310.

11. Peña AS, et al. Update on diagnosis of polycystic ovary syndrome during adolescence. Fertility and Sterility 2025;124(5), 956–961. https://doi.org/10.1016/j.fertnstert.2025.09.006.

12. Lim CYS, Loke KY, Varughese SM, Lee YS, Ng NBH. Evaluation and management of polycystic ovarian syndrome (PCOS) in adolescents with obesity: A scoping review of national and international obesity and PCOS management guidelines. Obesity Reviews 2025; https://doi.org/10.1111/obr.70072.

13. Zeng W, Gan D, Ou J, Tomlinson B. Global trends and health system impact on polycystic ovary syndrome: A comprehensive analysis of age-stratified females from 1990 to 2021. Frontiers in Reproductive Health 2025;7,

1642369.
https://doi.org/10.3389/frph.2025.16423691.

14. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med 2019;25, 44–56.
https://doi.org/10.1038/s41591-018-0300-7.

15. Esteva A, Robicquet A, Ramsundar B. et al. A guide to deep learning in healthcare. Nat Med 2019;25, 24–29. https://doi.org/10.1038/s41591-018-0316-z.

16. Wang J, Chen R, Long H, et al. Artificial intelligence in polycystic ovarian syndrome management: Past, present, and future. Radiologia Medica 2025; 130(9), 1409–1441. https://doi.org/10.1007/s11547-025-02032-9.

17. Ghaderzadeh M, Garavand A, Salehnasab C. Artificial intelligence in polycystic ovary syndrome: a systematic review of diagnostic and predictive applications. BMC medical informatics and decision making 2025; 25(1), 427. https://doi.org/10.1186/s12911-025-03255-6.

18. Arora KPP, Yadav H, Kavitha JK et al. Big data and machine learning for healthcare resource allocation and optimization. South Eastern European Journal of Public Health 2025;3998–4005. https://doi.org/10.70135/seejph.vi.3821.

19. Ning Y et al. Generative artificial intelligence and ethical considerations in health care: A scoping review and ethics checklist. The Lancet Digital Health 2025;6(11), e848–e856. https://doi.org/10.1016/S2589-7500(25)00190-5.

20. Murdoch B. Privacy and artificial intelligence: Challenges for protecting health information in a new era. BMC Medical Ethics 2021;22, Article 122. https://doi.org/10.1186/s12910-021-00687-3.