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INSULIN RESISTANCE AS A CENTRAL LINK: PREDIABETES, PCOS AND TYPE 2 DIABETES IN WOMEN

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Abstract

Diabetes mellitus is a growing global health concern nowadays in which women are more prone because of metabolic and hormonal risk factors. Insulin resistance act as a central link between prediabetes , polycystic ovary syndrome which eventually leads to type 2 diabetes mellitus . Even prediabetes in young women remains undiagnosed and left untreated. PCOS is a endocrine hormone disorder which is strongle associated with insulin sentivity. This paper explores the interconnection between prediabetes , PCOS and type 2 diabtes mellitus in women and emphasizing how insluin contributes to metabolic and hormonal disturbance in women. This studies also focus on classification of diabetes in women , role of lifestyle modification for prevention.

keywords: Resistance , diabetes mellitus , metabolic disturbance , lifestyle modification, nephropathy, retinopathy, neuropathy, infertility, endometrial cancer, haemoglobin A1c.

Introduction:

Insulin resistance is a metabolic condition in which body cells stops to use insulin properly which lead to elevated blood sugar level and if remains untreated it leads to development of type 2 diabetes mellitus and other hormonal changes in women which ultimately leads to PCOS. Type 2 diabetes mellitus is strongly associated with obesity and sedentary lifestyle. Diabetes mellitus can be diagnosed by measuring blood glucose levels while fasting or haemoglobin A1c levels.

- ❖ Normal fasting plasma glucose = 70-90mg/dl
- ❖ Normal hemoglobin A1c=below 5.7%(<39mmol/mol)

Diabetes mellitus can leads to severe complications in our body. Acute complications like hypoglycaemia means low blood sugar level symptoms like sweating , shaking, tachycardia , dizziness, anxiety, confusion and loss of consciousness and hyperglycaemia means high blood sugar level symptoms like fatigue, urination, thirst and even coma. Chronis complications like nephropathy, neuropathy, diabetic retinopathy, atherosclerosis and other severe heart problems. COS can be diagnosed by scans in which there are multiple small cyst present in the ovary. PCOS can lead to menstruation abnormalities , hair loss, hormonal acne and if left untreated it can also cause serious complications like infertility and endometrial cancer.

Prediabetes in Young Adults: Epidemiology and Risk Stratification

Prediabetes is an intermediate glycemic state associated with increased risk of type 2 diabetes mellitus and cardiovascular disease. Recent epidemiological evidence indicates a rising prevalence among adolescents and young adults, with approximately one in four individuals aged 19–34 years affected in the United States. This trend reflects earlier onset of metabolic dysfunction and increasing burden of cardiometabolic risk factors in younger populations.

1. Prevalence by Age, Sex, and BMI (NHANES 2005–2016)

- **Demographic Distribution of Prediabetes**

Variable	Adolescents (12–18 yrs)	Young Adults (19–34 yrs)
Overall prevalence	18.0%	24.0%
Male	22.5%	29.1%
Female	13.4%	18.8%
Obesity	25.7%	36.9%
Normal BMI	~16%	~16–17%
Predominant abnormality	IFG	IFG

Interpretation:
Prevalence increases with age and is consistently higher in males. Obesity is the strongest associated factor; however, non-obese individuals are also affected.

2. Temporal Trends in Prediabetes

- **Trend Analysis (US Youth Population)**

Period	Adolescents (%)	Young Adults (%)
1999–2002	11.6	—
2005–2010	~16.0	—
2011–2016	18.0	24.0

Interpretation:
A steady increase in prevalence is observed over time, indicating progressive population-level metabolic deterioration.

3. Glycemic Pattern Distribution

- **Pattern of Dysglycemia**

Feature	Young Population	Older Adults
Single abnormal marker	Predominant	Less common
Multiple abnormalities	Less frequent	More frequent
Dominant defect	Fasting glucose	Mixed abnormalities

Interpretation:
Younger individuals predominantly exhibit isolated impaired fasting glucose, suggesting early hepatic insulin resistance.

Discussion

Prediabetes is increasingly prevalent in young adults, with NHANES data indicating approximately 24% prevalence in individuals aged 19–34 years. The condition shows

a consistent upward trend over time and is more frequent in males and obese individuals.

The predominance of isolated impaired fasting glucose suggests early hepatic insulin resistance in younger populations. In contrast, older adults more commonly exhibit multiple glycemic abnormalities, indicating disease progression. The presence of prediabetes in normal-weight individuals highlights additional non-obesity-related mechanisms.

Conclusion

Prediabetes is common in young adults and demonstrates an increasing temporal trend. It is strongly associated with obesity and male sex but is also present in normal-weight individuals. Early-stage disease is characterized predominantly by impaired fasting glucose, supporting the need for early screening and preventive strategies.

PCOS, INSULIN RESISTANCE, AND RISK OF TYPE 2 DIABETES IN WOMEN

Trends

Before, Polycystic Ovary Syndrome (PCOS) considered as reproductive defect. But on the deep studies, it is now considered as a metabolic-endocrine disorder. Nowadays the cases of PCOS and diabetes are reporting increases in younger reproductive age of women. Over recent years, clinicians have been noticing a steady rise in cases of Polycystic Ovary Syndrome, particularly in urban populations. This increase seems to parallel modern lifestyle patterns such as reduced physical activity and dietary changes. We can't consider obesity as a marker for this, because it is being identified in lean women also. Studies suggest that more than half of women diagnosed with PCOS show some degree of insulin resistance. Another important trend is the earlier appearance of metabolic complications. Impaired glucose tolerance and Type 2 Diabetes Mellitus are now being detected at a younger age in women with PCOS compared to the general population.

Comparisons

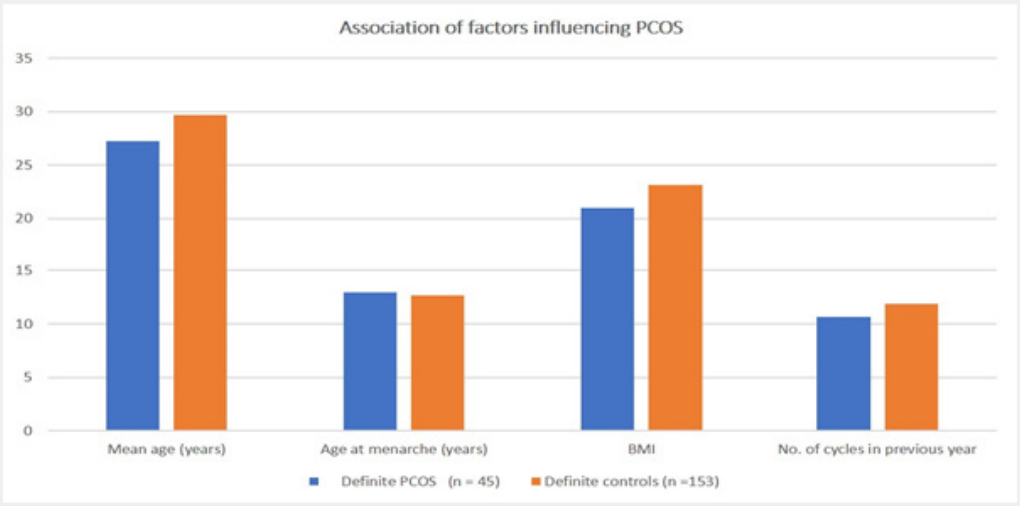
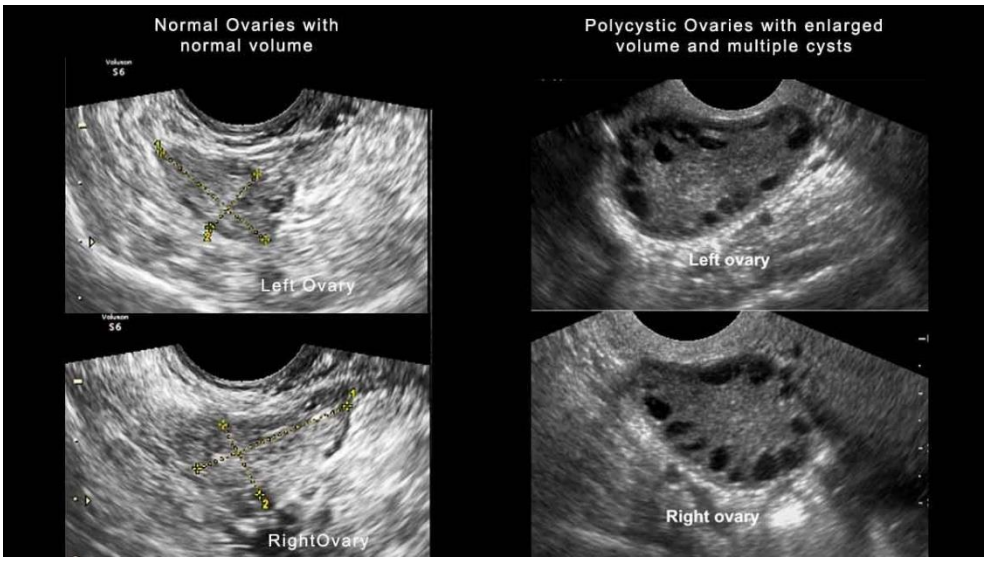


Figure 2: depicts the Association of factors influencing PCOS.

A comparison between women with PCOS and those without it reveals clear differences in metabolic function. In women with PCOS, insulin does not act efficiently at the cellular level. As a result, the body compensates by producing more insulin. This compensatory rise is not usually seen in women without PCOS unless other risk factors are present. Even within PCOS cases, variation exists. Some women who are not overweight still show biochemical evidence of insulin resistance. On the other hand, those with higher body weight often demonstrate more pronounced metabolic disturbances and a greater tendency toward diabetes. This comparison highlights an important point: while obesity can worsen insulin resistance, it is not necessary for its presence in PCOS.



❖ Discussion

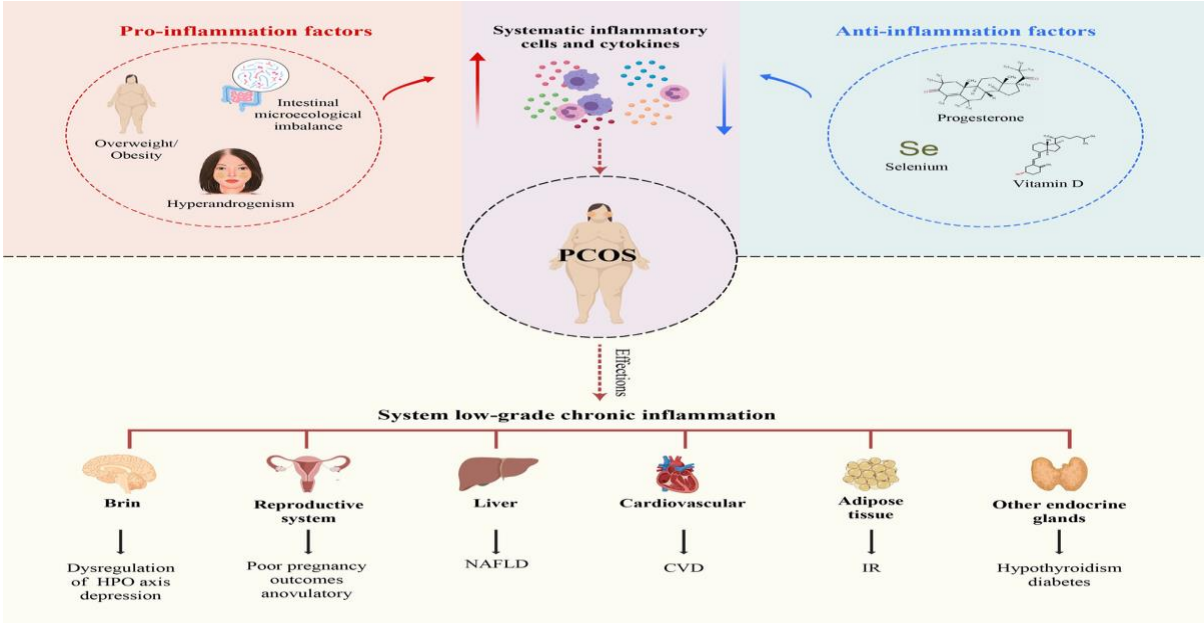


Figure 1:PCOS in women

The link between PCOS and diabetes becomes clearer when insulin resistance is considered as the central factor. When cells fail to respond properly to insulin, the pancreas increases insulin secretion to maintain normal blood glucose levels. Over time, this persistent demand leads to elevated insulin levels in circulation. These high insulin levels have effects beyond glucose metabolism. They stimulate ovarian cells to produce excess androgens, which contributes to the clinical features of PCOS. However, the continuous strain on insulin production is not sustainable. Gradually, pancreatic function may decline, and blood glucose levels begin to rise. This progression explains why women with PCOS are more likely to develop Type 2 diabetes later. From a clinical standpoint, this emphasizes the need for early identification and monitoring. Management should not be limited to symptomatic treatment but should also focus on reducing metabolic risk. Lifestyle changes and medications such as Metformin can play an important role in improving insulin sensitivity.

Conclusion

PCOS is increasingly being recognized as a condition that affects both reproductive and metabolic health. Insulin resistance acts as a key link connecting PCOS to the future development of Type 2 diabetes. Because this process begins early, timely intervention becomes essential. By focusing on early diagnosis, regular monitoring, and appropriate management, it is possible to reduce the long-term risk of diabetes in women with PCOS.

Role of Lifestyle Modification in Type 2 Diabetes and Its Prevention

1. Role of Lifestyle Modification

type 2 diabetes mellitus is a chronic metabolic disorder that is strongly influenced by lifestyle-related factors. unlike many other diseases, its development is closely associated with modifiable behaviors such as physical inactivity, unhealthy dietary patterns, and excess body weight.

regular physical activity is equally important. exercise enhances glucose uptake by skeletal muscles and reduces insulin resistance. over time, it also supports cardiovascular health and helps maintain a healthy body composition.

weight management is another key component. even a moderate reduction in body weight has been shown to significantly lower the risk of progression from prediabetes to diabetes. overall, lifestyle modification addresses the underlying metabolic disturbances rather than only controlling blood glucose levels.

these findings highlight that sustained lifestyle changes can produce long-term protective effects against the development of type 2 diabetes.

Setting	Regimen	Duration / Follow-up
Lifestyle Intervention (First-line)	**Calorie-restricted diet (low refined carbohydrates, high fiber) PLUS Physical activity ≥150 min/week (aerobic + resistance training) PLUS Weight loss target (5–10%)**	**Continuous; reassess every 3–6 months**

Setting	Regimen	Duration / Follow-up
Pharmacological (High-risk patients)	Metformin 500 mg PO once daily → titrate to 1000–2000 mg/day	6–12 months; monitor HbA1c every 3–6 months
Alternative Pharmacological (Obese patients)	GLP-1 receptor agonists (e.g., Liraglutide) PLUS lifestyle modification	Long-term; based on weight and glycemic response
PCOS-associated Prediabetes	Metformin 500–1500 mg/day PLUS hormonal therapy (OCPs if indicated)	6–12 months; reassess insulin resistance
Severe Insulin Resistance / Progression Risk	Combination: Metformin + GLP-1 agonist (selected cases)	Individualized; specialist supervision
Monitoring Only (Low-risk patients)	No drugs; strict lifestyle modification	Ongoing lifestyle follow-up

CONCLUSION

lifestyle modification remains the most effective and sustainable approach to preventing type 2 diabetes. evidence from major clinical trials demonstrates that changes in diet, physical activity, and body weight can significantly reduce disease risk and delay its onset.

while medications such as metformin have a supportive role, they do not replace the benefits achieved through consistent lifestyle changes. long-term prevention depends primarily on the adoption and maintenance of healthy behaviors.

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