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"EFFECTS OF OBESITY ON BIOCHEMICAL AND PHYSIOLOGICAL METABOLIC PATHWAYS IN WOMEN" A COMPARATIVE CLINICAL ANALYSIS

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Abstract

Introduction:
Obesity is a complex, multifactorial condition characterized by excessive adipose tissue accumulation that poses significant risks to overall health. In women obesity not only impacts physical appearance and quality of life but also plays a profound role in altering biochemical and physiological metabolic pathways. These alterations contribute to the onset and progression of various comorbid conditions including type 2 diabetes mellitus, cardiovascular diseases, polycystic ovary syndrome (PCOS) and certain cancers.

Objective:
To compare and evaluate the biochemical and physiological alterations in metabolic pathways associated with obese and non-obese in women

Material and Methods:
This study employed a comparative, cross-sectional clinical research design to assess and analyze the biochemical and physiological metabolic pathway alterations in obese and non-obese women. A total of 100 adult female participants, aged between 25 and 50 years, were recruited from outpatient department of Gulab Devi teaching hospital Lahore. By examining key metabolic markers and physiological indicators, this study seeks to provide deeper insights into the sex-specific implications of obesity and inform targeted approaches for prevention and management.

Results:
The study revealed significant alterations in several biochemical and physiological metabolic pathways among obese women compared to non-obese controls. Elevated levels of fasting glucose,

insulin, HOMA-IR index, triglycerides, and LDL-cholesterol were observed in the obese group, indicating a pronounced state of insulin resistance and dyslipidemia. Additionally, markers of inflammation such as CRP and hormonal profile markers were significantly higher in obese participants, while antioxidant enzyme activity was reduced.

Conclusion:

This comparative clinical study demonstrates that obesity in women is significantly associated with adverse alterations in biochemical and physiological metabolic pathways. These include impaired glucose metabolism, heightened insulin resistance, dyslipidemia, systemic inflammation, and reduced cardiovascular and respiratory efficiency. The findings underscore the complex interplay between obesity and metabolic dysfunctions, highlighting the importance of early detection, lifestyle modification, and targeted interventions to mitigate long-term health risks in obese women.

Keywords: Obesity, Metabolic pathways, Insulin resistance, Lipid profile, Inflammation

Introduction:

Obesity is a complex and multifactorial disease, represents a growing global health challenge. It is defined by the World Health Organization as an excessive accumulation of adipose tissue with a body mass index (BMI) of 30 kg/m² or greater, obesity is now recognized not merely as a cosmetic concern but as a significant metabolic disorder. Among women, the implications of obesity extend beyond reproductive complications and aesthetic perceptions. It deeply influences the biochemical and physiological pathways that govern metabolism, hormonal balance, cardiovascular health, and systemic inflammation[1, 2].

The rise in female obesity influenced by hormonal cycles, reproductive transitions such as pregnancy and menopause, and socio-cultural expectations, highlights the urgent need to explore how excess body fat alters women's metabolic functioning at the molecular level. Notably, the distribution of adiposity visceral versus subcutaneous fat along with sex-specific hormonal profiles makes the biochemical impact of obesity on women distinct from that in men[3].

Obesity is a global public health crisis and one of the most significant risk factors contributing to non-communicable diseases (NCDs) with its prevalence rising alarmingly, especially among women. According to the World Health Organization (WHO), over 650 million adults worldwide were obese as of 2022, with women disproportionately affected in many regions. Obesity in women is not only a matter of excessive body weight or altered physical appearance, it profoundly affects metabolic homeostasis, physiological function, reproductive health and overall quality of life. Obesity is recognized globally as a major contributor to chronic diseases such as type 2 diabetes mellitus (T2DM), cardiovascular diseases (CVD) and various hormonal disorders. In women, obesity presents unique challenges due to the interplay between adipose tissue and hormonal regulation. Adipose tissue is not merely an energy storage site but functions as an endocrine organ influencing systemic metabolism through adipokine secretion and inflammatory mediator release. The rising prevalence of obesity in women across all age groups calls for a deeper understanding of its impact on metabolic pathways[4, 5].

The physiological and biochemical alterations caused by obesity often begin subtly but can lead to severe metabolic disorders. Insulin resistance is one of the earliest manifestations, followed by dyslipidemia, oxidative stress, and systemic inflammation. These changes disrupt homeostasis and increase susceptibility to non-communicable diseases. Furthermore, in women, hormonal imbalances exacerbate these effects, impacting fertility, menstrual health, and overall well-being. Metabolic pathways, particularly those involving glucose and lipid metabolism, are notably disrupted in obese individuals. Insulin resistance, chronic low-grade inflammation, dyslipidemia and altered adipokine profiles are frequently observed, reflecting underlying biochemical imbalances. Moreover, physiological responses such as hormonal regulation, reproductive function and energy expenditure are also affected leading to a broad spectrum of clinical manifestations in women[6, 7].

Despite the established link between obesity and metabolic derangement, there remains a paucity of focused clinical studies that compare the specific biochemical and physiological changes in obese versus non-obese women. Most current literature generalizes findings across sexes, potentially overlooking unique female-specific metabolic signatures. Understanding these differences is crucial for developing personalized, gender-sensitive approaches to the prevention and management of obesity and its complications[8, 9].

Material and Methods:

This study employed a comparative cross-sectional clinical research design to assess and analyze the biochemical and physiological metabolic pathway alterations in obese and non-obese women. A total of 100 adult female participants, aged between 25 and 50 years, were recruited from medical outpatient department of Gulab Devi teaching hospital Lahore. Participants were divided into two groups based on their Body Mass Index (BMI). In group A: 50 obese women (BMI ≥ 30 kg/m²) and group B: 50 non-obese women (BMI 18.5–24.9 kg/m²)

Inclusion Criteria

Eligible participants were biologically female individuals aged between 25 and 50 years. Inclusion required the willingness to provide written informed consent and maintenance of a stable body weight, defined as no significant weight fluctuations over the preceding three months

Exclusion Criteria

Participants were excluded if they had a documented history of endocrine disorders (e.g., thyroid dysfunction or Cushing's syndrome) or were diagnosed with chronic illnesses such as cardiovascular disease, renal impairment, or hepatic dysfunction. Additional included current pregnancy or lactation, as well as the ongoing use of medications known to affect metabolic parameters (e.g., corticosteroids, antidiabetic agents, or lipid-lowering therapies).

Data Collection

All participants underwent a comprehensive clinical evaluation comprising demographic profiling, anthropometric assessment and detailed medical history documentation. As per anthropometric measurements Height (cm), measured using a stadiometer, Weight (kg), measured using a calibrated digital scale, Body Mass Index (BMI), calculated as weight (kg) / height (m²) and Waist and hip circumference, used to calculate waist-to-hip ratio (WHR). For Physiological Assessments Blood pressure (systolic and diastolic), measured using a digital sphygmomanometer, resting heart rate and Basal metabolic rate (BMR), estimated using the Harris-Benedict equation. The Biochemical Analyses done after an overnight fast (10–12 hours), venous blood samples were collected for the investigations which include Fasting blood glucose, insulin levels, and HOMA-IR index, lipid profile, liver function tests, renal function tests, CRP, leptin, adiponectin, cortisol, estradiol. All biochemical evaluations were conducted using standardized, automated analyzers to ensure accuracy and reproducibility. Data were analyzed using SPSS version 26. Results were expressed as mean ± standard deviation (SD). Independent t-tests compared means between groups. Multivariate analysis adjusted for age, physical activity, and diet. A p-value < 0.05 was considered statistically significant.

Results:

The study revealed significant alterations in several biochemical and physiological metabolic pathways among obese women compared to non-obese controls. Elevated levels of fasting glucose, insulin, HOMA-IR index, triglycerides, and LDL-cholesterol were observed in the obese group, indicating a pronounced state of insulin resistance and dyslipidemia. Additionally, markers of inflammation such as CRP and hormonal profile markers were significantly higher in obese participants, while antioxidant enzyme activity was reduced. Physiological assessments showed

increased resting heart rate, blood pressure, and decreased oxygen uptake capacity (VO_2 max), suggesting impaired cardiovascular and respiratory efficiency.

Table 1: Anthropometric and Physiological Parameters

Parameter	Obese (Group A) Mean ± SD	Non-Obese (Group B) Mean ± SD	p-value
Age (years)	37.6 ± 6.3	36.2 ± 5.9	0.178
BMI (kg/m²)	33.8 ± 2.4	22.4 ± 1.9	<0.001**
Waist Circumference (cm)	102.3 ± 8.7	76.5 ± 6.2	<0.001**
WHR	0.89 ± 0.05	0.76 ± 0.04	<0.001**
SBP (mmHg)	138.4 ± 12.1	118.2 ± 9.8	<0.001**
DBP (mmHg)	89.6 ± 8.3	75.4 ± 6.5	<0.001**
Resting HR (bpm)	82.5 ± 7.6	72.3 ± 6.9	<0.001**

Obese participants demonstrated significantly higher BMI, waist circumference, WHR, blood pressure, and resting heart rate compared to the non-obese group, indicating greater cardiovascular strain and central adiposity as mentioned in table 1.

Table 2: Biochemical Parameters

Parameter	Obese (Group A) Mean ± SD	Non-Obese (Group B) Mean ± SD	p-value
Fasting Glucose (mg/dL)	106.2 ± 14.1	89.4 ± 11.5	<0.001**
Insulin (µIU/mL)	18.5 ± 4.2	9.1 ± 2.8	<0.001**
HOMA-IR	4.9 ± 1.2	1.9 ± 0.6	<0.001**
Total Cholesterol (mg/dL)	210.3 ± 38.7	174.2 ± 29.4	<0.001**
HDL (mg/dL)	42.5 ± 6.9	54.7 ± 7.1	<0.001**
LDL (mg/dL)	134.1 ± 30.2	102.6 ± 22.3	<0.001**
Triglycerides (mg/dL)	168.4 ± 41.3	112.6 ± 30.2	<0.001**
CRP (mg/L)	5.6 ± 1.4	2.1 ± 0.9	<0.001**

Table 3: Hormonal and Adipokine Profile

Parameter	Obese (Group A) Mean ± SD	Non-Obese (Group B) Mean ± SD	p-value
Leptin (ng/mL)	28.7 ± 6.3	12.5 ± 3.8	<0.001**
Adiponectin (µg/mL)	6.1 ± 1.5	11.2 ± 2.1	<0.001**
Cortisol (µg/dL)	21.4 ± 4.3	15.8 ± 3.1	<0.001**
Estradiol (pg/mL)	92.7 ± 18.3	74.2 ± 16.4	0.002**

Obese women exhibited significant insulin resistance, dyslipidemia, and systemic inflammation as evidenced by elevated HOMA-IR, triglycerides, CRP, and reduced HDL levels as highlighted in table 2. The hormonal profile of obese women revealed significantly elevated leptin and cortisol levels and a marked reduction in adiponectin, indicating hormonal dysregulation and inflammation-promoting adipose activity as mentioned in table 3

Discussions:

This study provides robust evidence that obesity in women is associated with extensive metabolic disturbances. The significant increase in BMI, WHR, and blood pressure reflects the burden of central obesity, a known predictor of metabolic syndrome and cardiovascular disease. Higher insulin and HOMA-IR levels suggest impaired insulin sensitivity, a precursor to type 2 diabetes mellitus. These results align with findings by[10]. Elevated LDL, triglycerides, and reduced HDL in the obese group represent a classic atherogenic lipid profile. This lipid imbalance enhances the risk for ischemic heart disease and stroke. Elevated leptin with low adiponectin levels supports the theory of "adiposopathy"

or "sick fat syndrome," where dysfunctional adipose tissue exacerbates metabolic dysfunctions[11]. The significantly raised CRP level is indicative of chronic low-grade inflammation, a hallmark of obesity and a contributor to endothelial dysfunction and atherosclerosis[12]. The increase in estradiol and cortisol levels may reflect enhanced peripheral conversion of androgens in adipose tissue and stress-induced HPA axis stimulation, respectively.

Implications:
The observed biochemical and physiological disturbances suggest that obese women are at significantly greater risk for metabolic syndrome, cardiovascular events, endocrine abnormalities, and infertility-related conditions such as PCOS. Understanding these pathway changes offers critical insights for early diagnosis, risk stratification, and targeted therapy.

Limitations:
While the study provides valuable insights, limitations include a relatively small sample size, reliance on cross-sectional data, and lack of longitudinal follow-up. Future studies should incorporate larger, diverse populations and examine the effects of specific interventions over time. Additionally, hormonal fluctuations due to menstrual cycle phases were not standardized, which may have introduced some variability in estrogen and progesterone data.

Conclusion:
Obesity in women induces profound alterations in key metabolic and hormonal pathways, manifesting as insulin resistance, dyslipidemia, inflammation, and endocrine dysfunction. These findings underscore the urgency for routine metabolic screening and gender-specific intervention strategies in obese female populations. Preventive health programs must integrate lifestyle modification, nutritional counseling, and early therapeutic interventions to mitigate the long-term complications associated with obesity.

Author Contribution:

1-Amna Riaz Assistant Professor, Department of Endocrinology, Al-Aleem Medical College, Gulab Devi Teaching Hospital Lahore, Pakistan	**Conceptualization & Manuscript writing**
2-Haseeb Ahmed Khan Assistant Professor, Department of Physiology, Services Institute of Medical Sciences, Services Hospital Lahore, Pakistan	**Literature Review & Editing**
3-Asifa Karamat Associate Professor, Department of Pulmonology, Al-Aleem Medical College, Gulab Devi Teaching Hospital Lahore, Pakistan	**Critical Review of Manuscript writing**
4-Junaid Iqbal Assistant Professor, Department of Physiology, Sahara Medical College, The Sahara University Narowal, Pakistan	**Data Collection**
5-Mehwish Iftikhar Assistant Professor, Department of Biochemistry, King Edward Medical University Lahore, Pakistan	**Data Analysis**
6-Muhammad Abdullah Asghar Senior Registrar, Department of Medicine, FMH College of Medicine & Dentistry, Fatima Memorial Hospital Lahore, Pakistan	**Supervision**

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