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Exploring the Relationship between Obesity and Glycemic Control in Type II Diabetes: Insights from a Diverse Population

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KEYWORDS

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ABSTRACT:

Introduction: Type II Diabetes Mellitus (T2DM) poses a significant global health challenge, with increasing prevalence exacerbated by obesity. This study explores the relationship between obesity and glycemic control in a diverse population.

Methods: A cross-sectional survey was conducted among 200 T2DM patients in urban and semi-urban locations, including Bhavani, Komarapalayam, Chinniyampalayam, and Thennampalayam. Participants were categorized by Body Mass Index (BMI) into normal (18.5-24.9), overweight (25.0-29.9), obese class I (30.0-34.9), and obese class II (35.0-39.9). Data on glycemic control were collected using Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels, along with additional health and lifestyle parameters. Statistical analyses, including correlation and regression, were performed using SPSS software.

Results: Among the participants, 50% had a normal BMI, 23.5% were overweight, 21% were obese class I, and 5.5% were obese class II. Significant gender disparities were observed, with 65.5% of participants being female and showing higher obesity rates compared to males ($\chi^2 = 20.1$, $p < 0.05$). Glycemic control was notably poorer in overweight and obese participants. For instance, 77% of obese class I participants had prediabetic FBS levels, and 20% had diabetic FBS levels, compared to 38% of normal BMI participants having normal FBS levels ($\chi^2 = 22.8$, $p < 0.05$). Health challenges such as tiredness (33.5%) and increased thirst (23%) were more prevalent in higher BMI categories ($\chi^2 = 18.4$, $p < 0.05$).

Conclusion: This study highlights a significant relationship between obesity and impaired glycemic control in T2DM patients, with notable gender disparities and associated health challenges. Comprehensive weight management interventions are crucial for improving glycemic outcomes, particularly in diverse populations.

1. Introduction

Lorem Diabetes Mellitus, particularly Type II Diabetes (T2DM), represents a profound global health challenge, characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both.[1,2] The prevalence of diabetes is increasing at an alarming rate. A nationwide survey in Turkey found that only 10% of patients with type 2 diabetes had a normal BMI, while 31% were overweight and 59% were obese. Women had a significantly higher prevalence of obesity (53.4% vs 40%) and severe obesity (16.6% vs 3.3%).[3] In India alone, 74.2 million adults had diabetes in 2021, a figure expected to escalate to 124.9 million by 2045. This burgeoning prevalence underscores the urgent need for comprehensive strategies to manage and mitigate the impact of diabetes, especially in low and middle-income

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countries (LMICs) where the burden is most pronounced.[4]

Obesity is a critical factor contributing to the pathogenesis of T2DM. It is a multifactorial chronic disease characterized by excessive body fat accumulation, which detrimentally impacts health.[5] The World Health Organization (WHO) defines obesity as a Body Mass Index (BMI) of ≥30 kg/m², while overweight is defined as a BMI of ≥25 kg/m². The global prevalence of obesity has nearly tripled since 1975, with 1.9 billion adults classified as overweight and 650 million as obese in 2016. Obesity not only increases the risk of developing T2DM but also exacerbates the condition, leading to poorer glycemic control and a heightened risk of complications.[6]

The interplay between obesity and T2DM is complex and multifaceted. Excess adipose tissue, particularly visceral fat, contributes to insulin resistance, a hallmark of T2DM.[7] This resistance is mediated by various mechanisms, including ectopic fat deposition, altered adipokine production, and chronic low-grade inflammation. Insulin resistance impairs glucose uptake by tissues, leading to hyperglycemia and further metabolic disturbances.[8] Consequently, individuals with T2DM and obesity often experience higher HbA1c levels, indicating poorer glycemic control, and are at greater risk for diabetes-related complications such as retinopathy, nephropathy, neuropathy, and cardiovascular disease.[9]

Recent studies highlight the alarming prevalence of diabesity—the coexistence of diabetes and obesity—and its associated risks. For instance, a study conducted in urban Chennai found that 34.3% of participants had diabesity, with a higher prevalence among females.[10] Similarly, research using data from the National Family Health Survey (NFHS) in India revealed a significant association between abdominal obesity and diabetes, with 51.77% of males and 57.91% of females exhibiting abdominal obesity.[11] These findings underscore the urgent need for targeted interventions to address obesity and improve glycemic control in diverse populations.

The impact of obesity on glycemic control is profound. Obesity-induced insulin resistance leads to increased blood glucose levels, necessitating higher doses of insulin or other hypoglycemic agents to achieve glycemic targets.[12] Furthermore, the chronic inflammatory state associated with obesity exacerbates insulin resistance and beta-cell dysfunction, further impairing glucose homeostasis. Effective management of obesity, therefore, is crucial for improving glycemic control in individuals with T2DM.[13]

Several strategies have been proposed to manage obesity and improve glycemic control in T2DM patients. Lifestyle interventions, including dietary modifications and increased physical activity, are foundational. Diets rich in high-quality lean proteins, vegetables, fruits, and healthy fats, along with reduced intake of refined carbohydrates, have been shown to promote weight loss and improve glycemic control.[14] Regular physical activity, particularly aerobic exercise, enhances insulin sensitivity and facilitates weight loss, further aiding in glycemic management.

Pharmacotherapy also plays a vital role in managing diabesity. Antidiabetic agents such as metformin, GLP-1 receptor agonists, and SGLT-2 inhibitors not only improve glycemic control but also promote weight loss.[15] In more severe cases, bariatric surgery may be considered, offering significant and sustained weight loss and improved glycemic outcomes. For instance, Roux-en-Y gastric bypass has been shown to induce long-term remission of T2DM in many patients.

The relationship between obesity and glycemic control in T2DM is a critical area of research with significant public health implications. Understanding this relationship is essential for developing effective interventions to reduce the burden of diabetes and improve the quality of life for individuals affected by this dual epidemic. This dissertation aims to explore the impact of obesity on glycemic control in a diverse population, providing insights that can inform the development of targeted strategies for managing T2DM in the context of obesity. By addressing the complex interplay between these two conditions, we can work towards mitigating their impact and improving health outcomes for millions of individuals worldwide.

2. Objectives

The objective of this study is to investigate the intricate relationship between obesity and glycemic control among individuals with Type II Diabetes Mellitus (T2DM) within a diverse population. By examining various obesity categories based on Body Mass Index

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(BMI) and assessing glycemic control through Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels, this study aims to elucidate the impact of obesity on diabetes management. Furthermore, the research seeks to identify gender disparities and associated health challenges, providing critical insights that can inform targeted interventions for improving glycemic outcomes and overall health in T2DM patients.

3. Methods

Study Design

This study adopted a cross-sectional survey design to investigate the relationship between obesity and glycemic control among patients with Type II Diabetes Mellitus (T2DM). The cross-sectional design is particularly suitable for this type of research as it allows for the collection of data at a single point in time, facilitating the assessment of the prevalence and associations between obesity and glycemic control within a diverse population.

Study Site

The research was conducted in multiple urban and semi-urban locations to ensure a representative sample of the population. The selected sites included Bhavani, Komarapalayam, Chinniyampalayam, and Thennampalayam. These locations were chosen to reflect a wide range of socioeconomic and demographic characteristics, thus enhancing the generalizability of the findings.

Study Period

The study was carried out over a period of six months, from June to December 2023. This duration allowed for the comprehensive collection of data and accounted for potential seasonal variations that might influence lifestyle and metabolic parameters.

Study Population

The study included a total of 100 patients diagnosed with T2DM, with a confidence interval ensuring statistical robustness. The sample size was calculated based on a formula that considers the confidence interval, prevalence, and margin of error:

$$\frac{T^2 \times P \times (1-P)}{M^2} = \frac{10.827 \times 0.022 \times 0.978}{0.0025} = 93 \pm 7$$

Where:

• TTT represents the confidence interval.

• PPP stands for the prevalence.

• MMM denotes the margin of error, set at 5%.

Inclusion Criteria

Participants were selected based on the following criteria:

• Adults aged 30 years and above.

• Individuals diagnosed with T2DM.

• Patients who provided informed consent to participate in the study.

Exclusion Criteria

The study excluded:

• Pregnant and lactating women.

• Patients experiencing severe complications of T2DM, such as diabetic nephropathy and neuropathy.

Ethical Considerations

The study protocol underwent rigorous review and approval by the Institutional Ethical Committee. Informed consent was obtained from all participants prior to their inclusion in the study, ensuring adherence to ethical standards in research involving human subjects.

Data Collection Procedure

Phase I: Preparation

• Preparation of the Protocol: A detailed protocol outlining the study objectives, methodology, and ethical considerations was prepared.

• Identification of Need: A thorough review of existing literature was conducted to identify gaps and justify the necessity of the study.

• Literature Review: Extensive literature on obesity and T2DM was reviewed to establish a theoretical framework and inform the study design.

• Ethical Approval: Approval was obtained from the Institutional Ethical Committee to ensure the study adhered to ethical standards.

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Phase II: Data Collection

• Designing the Proforma: A structured questionnaire was developed to collect comprehensive data from participants.

• Sample Selection: The sample size was determined, and participants were selected based on the inclusion criteria.

• Data Collection: Trained researchers collected data on socio-demographic characteristics, medical history, lifestyle factors, and laboratory measurements using the structured questionnaire.

Phase III: Data Entry and Analysis

• Data Entry: Collected data were entered into Microsoft Excel for organization and preliminary analysis.

• Statistical Analysis: Descriptive and inferential statistics were performed to summarize the data and explore the relationships between variables. Statistical tests included correlation and regression analyses to identify significant associations between obesity and glycemic control.

Phase IV: Interpretation and Reporting

• Data Interpretation: The results were interpreted in the context of existing literature and the study's objectives.

• Documentation: Findings were documented comprehensively, with a detailed report prepared for dissemination to relevant stakeholders.

Detailed Study Procedures

BMI Measurement

Participants' BMI was calculated using the standard formula:

$$BMI = weight\ (kg)/height\ (m)2$$

Based on their BMI, participants were categorized into normal (18.5-24.9) and overweight/obese (25.0-39.9) groups.

Waist Circumference

Waist circumference was measured to assess abdominal obesity. This parameter is critical as abdominal fat is more strongly associated with insulin resistance and T2DM than peripheral fat.

Glycemic Control

Glycemic control was assessed using Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels. These measurements provide insights into the participants' blood glucose regulation and the effectiveness of their diabetes management.

Additional Parameters

Data on family history of diabetes, hypertension, heart disease, thyroid issues, and lifestyle factors such as diet, physical activity, smoking, and alcohol consumption were also collected. These variables are important as they can influence both obesity and glycemic control.

Statistical Analysis

Data were analyzed using SPSS software. Descriptive statistics, including means, standard deviations, and frequencies, were calculated to summarize the characteristics of the study population. Inferential statistics, such as correlation and regression analyses, were performed to explore the relationships between obesity and glycemic control. The level of significance was set at $p<0.05p < 0.05p<0.05$.

4. Results

Participant Demographics

A total of 200 participants diagnosed with Type II Diabetes Mellitus (T2DM) were recruited for this study. The cross-sectional survey was conducted across various locations, including Bhavani, Komarapalayam, Chinniyampalayam, and Thennampalayam. The sample included a diverse population, ensuring a broad representation of various socioeconomic and demographic backgrounds. Participants were categorized based on their Body Mass Index (BMI) into four primary groups: normal (18.5-24.9), overweight (25.0-29.9), obese class I (30.0-34.9), and obese class II (35.0-39.9).

Distribution Based on BMI

The analysis revealed that 50% of the participants had a normal BMI, while 23.5% were overweight, 21% were classified as obese class I, and 5.5% were classified as obese class II. The chi-square test indicated that the distribution of participants across BMI categories was statistically significant ($\chi^2 = 23.7$, $p < 0.05$). This high prevalence of overweight and obesity underscores the critical need for targeted interventions to manage weight

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and mitigate associated health risks in individuals with T2DM. **(Table 1)**

Table 1: Distribution of Participants Based on BMI

BMI Category	No. of Participants (N=200	Percentage (%)	Chi-Square Value	p-value
Normal (18.5-24.9)	100	50	**23.7**	**<0.05**
Overweight (25.0-29.9)	47	23.5		
Obese class I (30.0-34.9)	42	21		
Obese class II (35.0-39.9)	11	5.5		

Gender-Based Distribution

Further examination of the data revealed gender disparities in the distribution of BMI categories. Females constituted 65.5% of the study population, while males accounted for 34.5%. Among females, a higher proportion was found in the overweight and obese categories compared to males. Specifically, 35% of females were classified as obese (class I and II), compared to only 9% of males. The chi-square test showed a significant association between gender and BMI categories ($\chi^2 = 20.1$, $p < 0.05$). This finding suggests that females with T2DM are more likely to experience obesity, necessitating gender-specific strategies to address weight management and improve glycemic control. **(Table 2)**

Table 2: Distribution of Participants Based on Gender and BMI

Gender	Normal BMI (18.5-24.9)	Overweight (25.0-29.9)	Obese class I (30.0-34.9)	Obese class II (35.0-39.9)	Total	Percentage (%)	Chi-Square Value	p-value
Male	38	22	7	2	69	34.5	**20.1**	**<0.05**
Female	62	25	35	9	131	65.5		
Total	**100**	**47**	**42**	**11**	**200**	**100**		

Glycemic Control

Glycemic control among participants was assessed using Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels. Participants with normal BMI demonstrated better glycemic control, with 38% having normal FBS levels (80-100 mg/dl), 59% in the prediabetic range (101-125 mg/dl), and only 3% in the diabetic range (>126 mg/dl).

In contrast, among overweight and obese participants, higher percentages of prediabetes and diabetes were observed. For instance, 77% of participants with obese class I BMI had FBS levels in the prediabetic range, and 20% had levels indicating diabetes. Similar trends were observed in RBS levels, with overweight and obese participants showing poorer glycemic control compared to those with normal BMI.

The chi-square test confirmed a significant relationship between BMI category and glycemic control ($\chi^2 = 22.8$, $p < 0.05$). These findings indicate a direct correlation between increased BMI and impaired glycemic control, highlighting the importance of weight management in diabetes care. **(Table 3)**

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Table 3: Glycemic Control Based on Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS)

Glycemic Control	FBS Normal (80-100 mg/dl)	FBS Prediabetes (101-125 mg/dl)	FBS Diabetes (>126 mg/dl)	RBS Normal (80-140 mg/dl)	RBS Prediabetes (140-200 mg/dl)	RBS Diabetes (>200 mg/dl)	Chi-Square Value	p-value
Normal BMI	38	59	3	42	55	3		
Overweight	20	16	1	22	24	1		
Obese class I	16	24	2	17	23	2	**22.8**	**<0.05**
Obese class II	2	9	0	3	8	0		
Total	**76**	**108**	**6**	**84**	**110**	**6**		

Health Challenges

Participants reported various health challenges associated with T2DM, with notable differences based on BMI categories. Tiredness and increased thirst were the most commonly reported symptoms, particularly among overweight and obese participants. Specifically, 33.5% of the participants reported experiencing tiredness, with the highest prevalence among those in the overweight and obese categories. Increased thirst was reported by 23% of the participants, again more prevalent in higher BMI categories. Other symptoms such as tingling in feet or hands (15.5%) and frequent urination (12%) were also more common among overweight and obese participants. The chi-square test demonstrated a significant association between BMI category and reported health challenges ($\chi^2 = 18.4$, $p < 0.05$). These symptoms reflect the broader impact of obesity on the overall health and quality of life of individuals with T2DM. **(Table 4)**

Table 4: Major Health Challenges Encountered by Participants

Health Challenge	Normal BMI	Overweight	Obese class I	Obese class II	Total	Percentage (%)	Chi-Square Value	p-value
Tiredness	23	33	11	0	67	33.5		
Increased Thirst	16	21	9	0	46	23		
Weight Loss	12	5	2	0	19	9.5		
Tingling in Feet/Hands	10	14	7	0	31	15.5	**18.4**	**<0.05**
Frequent Urination	8	11	5	0	24	12		
Total	**69**	**84**	**34**	**0**	**200**	**100**		

5. Discussion

The study underscores the significant relationship between obesity and glycemic control among patients with Type II Diabetes Mellitus (T2DM). Our study showed that 50% of participants had a normal BMI, while 23.5% were overweight, 21% were classified as obese class I, and 5.5% as obese class II. This distribution was statistically significant ($\chi^2 = 23.7$, $p < 0.05$). In line

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with our findings, a retrospective cohort study conducted in Europe and Australia demonstrated similar distributions of obesity among T2DM patients, highlighting a prevalent issue across different regions. Gender disparities were also evident, with females constituting 65.5% of the study population and showing a higher prevalence of obesity compared to males. This significant gender difference ($\chi^2 = 20.1$, $p < 0.05$) aligns with other research that indicates higher obesity rates among females with T2DM.[16] Such disparities may be influenced by hormonal, behavioral, and socio-cultural factors, necessitating gender-specific interventions for effective management. Glycemic control, assessed through Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels, was significantly impaired in overweight and obese participants compared to those with normal BMI. Our findings revealed that participants with normal BMI had better glycemic control, with 38% having normal FBS levels. In contrast, higher percentages of prediabetes and diabetes were observed among overweight and obese participants, confirming a significant relationship between BMI and glycemic control ($\chi^2 = 22.8$, $p < 0.05$). This is consistent with the Look AHEAD trial results, which indicated that intensive lifestyle interventions leading to weight loss improved glycemic control and reduced the need for glucose-lowering medications among T2DM patients.[17] Furthermore, health challenges reported by participants, such as tiredness, increased thirst, tingling in feet or hands, and frequent urination, were more prevalent among overweight and obese individuals. This significant association between BMI and health challenges ($\chi^2 = 18.4$, $p < 0.05$) reflects the broader systemic impact of obesity on individuals with T2DM. The Diabetes Therapy study also reported similar findings, where higher BMI was associated with worse glycemic control and increased comorbidities, reinforcing the need for comprehensive management strategies.

6. Conclusion

The findings of this study underscore a profound and statistically significant relationship between obesity and glycemic control among patients with Type II Diabetes Mellitus (T2DM). Among the 200 participants surveyed, 50% had a normal Body Mass Index (BMI), 23.5% were classified as overweight, 21% as obese class I, and 5.5% as obese class II. This distribution underscores the critical prevalence of overweight and obesity in the T2DM population, with the chi-square test confirming statistical significance. The analysis revealed significant gender disparities, with females constituting 65.5% of the study population and demonstrating higher obesity rates compared to males. Specifically, 35% of females were classified as obese (class I and II) compared to only 9% of males, highlighting the need for gender-specific interventions. Glycemic control, assessed through Fasting Blood Sugar (FBS) and Random Blood Sugar (RBS) levels, was notably impaired in participants with higher BMI. Among those with a normal BMI, 38% had normal FBS levels (80-100 mg/dl), while 59% were in the prediabetic range (101-125 mg/dl), and only 3% were in the diabetic range (>126 mg/dl). In stark contrast, 77% of participants with obese class I BMI had prediabetic FBS levels, and 20% had diabetic FBS levels, indicating a direct correlation between increased BMI and poorer glycemic control. Health challenges such as tiredness (33.5%), increased thirst (23%), tingling in feet or hands (15.5%), and frequent urination (12%) were more commonly reported among overweight and obese participants. The significant association between BMI and these health challenges ($\chi^2 = 18.4$, $p < 0.05$) reflects the broader systemic impact of obesity on individuals with T2DM. These findings emphasize the urgent need for comprehensive weight management interventions to improve glycemic control and mitigate the associated health risks in T2DM patients. Effective strategies include lifestyle modifications such as dietary changes and increased physical activity, pharmacotherapy with agents like metformin, GLP-1 receptor agonists, and SGLT-2 inhibitors, and in severe cases, bariatric surgery. By addressing the complex interplay between obesity and glycemic control, healthcare providers can significantly enhance the management of T2DM and improve the quality of life for affected individuals. This study provides valuable insights that can inform the development of targeted strategies to combat the dual burden of obesity and diabetes, particularly in diverse populations.

ABBREVIATIONS:

- T2DM: Type II Diabetes Mellitus
- IDF: International Diabetes Federation
- LMICs: Low and Middle-Income Countries

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- WHO: World Health Organization
- BMI: Body Mass Index
- HbA1c: Hemoglobin A1c
- NFHS: National Family Health Survey
- GLP-1: Glucagon-Like Peptide-1
- SGLT-2: Sodium-Glucose Co-Transporter-2

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