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Effect of Metformin and Glimepiride on Glycated Haemoglobin and Lipid Profile Levels in Patients with Type 2 Diabetes Mellitus

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Abstract

This study examined the effects of metformin and glimepiride on glycated hemoglobin (HbA1c) and lipid profiles in patients with type 2 diabetes mellitus (T2DM). The study was conducted over six months in an outpatient diabetes clinic. It includes adults aged 18-70 with HbA1c levels between 7% and 10%. Participants were treated with metformin (500-1000 mg) and glimepiride (1-4 mg), with dose adjustments based on glycemic control. HbA1c, fasting blood glucose, and lipid profiles were assessed at baseline and after six months. The results showed significant improvements in HbA1c, lipid profiles, mental health, and patient satisfaction. HbA1c levels decreased from 7.02% to 6.23% ($p<0.001$), and lipid profiles improved, with triglycerides dropping from 245 mg/dl to 180 mg/dl, total cholesterol from 271 mg/dl to 225 mg/dl, LDL from 165 mg/dl to 151 mg/dl, and HDL increasing from 35 mg/dl to 42 mg/dl ($p<0.001$). Depression and anxiety scores also improved significantly, along with higher patient satisfaction. The study concluded that metformin and glimepiride effectively improved glycemic control, lipid metabolism, and mental health in T2DM patients, highlighting their broader benefits beyond glucose regulation. These findings support their role in comprehensive diabetes management.

Keywords: AEZ Glycated hemoglobin (HbA1c), LDL, HDL.

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Introduction

Chronic hyperglycemia, a hallmark of type 2 diabetes mellitus (T2DM), is a major cause of morbidity and mortality worldwide. Effective management involves controlling blood glucose levels and addressing lipid abnormalities to reduce cardiovascular risks. Metformin and glimepiride, with distinct mechanisms of action, are commonly used antidiabetic medications (Ingle and Talele 2011). Metformin, a first-line antihyperglycemic agent, improves insulin sensitivity and reduces hepatic glucose production, typically lowering HbA1c by 1-2% and improving lipid profiles by reducing total cholesterol, LDL cholesterol, and triglycerides while slightly increasing HDL cholesterol (Satin et al. 2021). Glimepiride, a sulfonylurea, stimulates insulin release, lowering HbA1c by 1-1.5%, but has less pronounced effects on lipid profiles and a higher risk of hypoglycemia. Combination therapy with metformin and glimepiride achieves better glycemic control, often resulting in greater HbA1c reductions without significantly altering lipid profiles beyond metformin's effects. Regional variations exist in the impact of these drugs due to differences in healthcare practices, genetics, dietary habits, and lifestyle (Cesur et al. 2007). In Asia, combination therapy is common due to high T2DM prevalence, showing substantial HbA1c reduction and favorable lipid changes. Europe and North America emphasize metformin as first-line therapy, with careful use of glimepiride to avoid hypoglycemia. In Africa and Latin America, varying access to medications and healthcare infrastructure influences antidiabetic therapy choices, with metformin remaining central to T2DM management and glimepiride used where available and appropriate. South Asia, encompassing countries like India, Bangladesh, Pakistan, Sri Lanka, and Nepal, has one of the highest burdens of T2DM globally. Factors such as high-calorie diets, physical inactivity, and genetic susceptibility contribute to this epidemic. The management of T2DM in this region is complicated by limited healthcare infrastructure, economic constraints, and varying levels of patient awareness and education about the disease. Metformin is a biguanide that lowers blood glucose levels primarily by decreasing hepatic glucose production and improving insulin sensitivity. It is the first-line treatment for T2DM due to its efficacy, safety profile, and benefits in weight management and cardiovascular risk reduction (Hassan and Abd-Allah 2015). Glimepiride is a sulfonylurea that causes the beta cells of the pancreas to secrete insulin. It is often used as an add-on therapy when metformin alone does not achieve adequate glycemic control. Studies in South Asian populations have shown that both metformin and glimepiride effectively reduce HbA1c levels, a

critical marker of long-term glycemic control (Valsaraj et al. 2009). However, the extent of HbA1c reduction can vary: Metformin typically reduces HbA1c levels by 1-2%. Its use is associated with a low risk of hypoglycemia and beneficial effects on body weight. Glimepiride can lower HbA_1c by 1-1.5%, but its use carries a higher risk of hypoglycemia and potential weight gain. Combining metformin and glimepiride often results in a more significant reduction in HbA1c than either drug alone, making combination therapy a common approach in South Asia (Valsaraj et al. 2009, Hassan and Abd-Allah 2015). Millions of people in Bangladesh suffer from type 2 diabetes mellitus (T2DM), a serious public health concern that requires efficient treatment to avoid complications and improve patient quality of life. This study investigates the combined effects of metformin and glimepiride on Glycated Hemoglobin (HbA1c) and lipid profiles in Bangladeshi T2DM patients at a large tertiary care hospital in Bangladesh. Regular follow-ups include blood sample collection for HbA1c and lipid profiles (total cholesterol, LDL, HDL, triglycerides), alongside other clinical data like blood pressure and body weight. The expected outcomes are a significant reduction in HbA1c and improved lipid profiles, with the combination therapy anticipated to enhance glycemic control and manage dyslipidemia effectively. Both medications are generally well-tolerated, with side effects such as hypoglycemia and gastrointestinal issues being monitored. The study's findings could significantly impact T2DM treatment protocols in Bangladesh, promoting the adoption of combination therapy for better glycemic and lipid control, and emphasizing the importance of comprehensive T2DM management, including lifestyle and dietary modifications.

This study is critical as it addresses the escalating public health challenge of type 2 diabetes mellitus (T2DM) in Bangladesh, a country where millions are affected by this condition. Effective management of T2DM is essential to prevent severe complications, reduce healthcare costs, and improve patient quality of life. By examining the combined effects of metformin and glimepiride on Glycated Hemoglobin (HbA1c) and lipid profiles, the study aims to provide evidence-based insights into optimizing treatment protocols (Abdel-Moneim et al. 2019). The findings could lead to improved glycemic and lipid control, reducing the risk of cardiovascular diseases and other diabetes-related complications. Moreover, the study emphasizes the importance of regular monitoring and comprehensive management, including lifestyle and dietary interventions tailored to the Bangladeshi context. This research has the potential to significantly impact public health strategies, enhancing the standard of care for T2DM patients in Bangladesh and potentially in other similar settings.

Materials and Methods

Study design: This study was designed as a before-and-after observational study conducted over a period of 6 months (February 2024 to July 2024). The research was carried out in an outpatient diabetes clinic at a tertiary care hospital. Informed consent was obtained from the participants. The study aimed to evaluate the effect of metformin and glimepiride on glycated haemoglobin (HbA1c) levels and lipid profiles in patients with type 2 diabetes mellitus (T2DM).

Study location: Data were collected from the Ahad Diabetic and Health Complex and the 250-bed General Hospital of Jashore, Bangladesh.

Study population: The study included adult patients aged 18-70 years who had been diagnosed with type 2 diabetes mellitus for at least one year. Patients had HbA1c levels between 7% and 10% at baseline and were not currently on metformin or glimepiride. From Eligible participants were taken informed consent to participate in the study. Inclusion Criteria for participants were- i) Adults aged 18-70 years, ii) Diagnosed with type 2 diabetes mellitus (T2DM) for at least one year, iii) HbA1c levels between 7% and 10%, iv) Not currently on metformin or glimepiride, v) Willing to provide informed consent. Exclusion Criteria for the participants were i) Type 1 diabetes or secondary diabetes, ii) Severe renal or hepatic impairment, iii) History of cardiovascular disease in the past 6 months, iv) Pregnant or breastfeeding women, and v) Patients on insulin or other oral hypoglycemic agents besides metformin or glimepiride.

Sample size

The sample size was calculated using the following equation:

$$n = \frac{z^2 pq}{d^2};\ n = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.05^2} = 384.16 \approx 384$$

Here,
n = number of samples
z = 1.96 (95% confidence level)
p = prevalence estimate (50% or 0.5)
q = 1-p
d = Precession of the prevalence estimate (10% of 0.5)

We initially calculated a sample size of 384 individuals; however, to enhance the study's robustness, we surpassed this estimate by recruiting a total of 391 participants after excluding the incomplete responses.

Baseline assessment: Eligible participants were recruited from the outpatient diabetes clinic, and written informed consent was obtained from all patients. Detailed medical history was collected, including the duration of diabetes, current medications, and comorbidities. A thorough physical examination was performed for each participant, and baseline measurements were recorded, including Glycated hemoglobin (HbA1c), Fasting blood glucose (FBG), Lipid profile (total cholesterol, LDL, HDL, triglycerides), Liver function tests (ALT, AST), Renal function tests (serum creatinine, eGFR).

Intervention: In the Metformin and Glimepiride Group, participants were initially started on a dosage of 500 mg of metformin twice daily. The dosage was titrated over 4 weeks based on the patient's tolerance and glycemic response, with the maximum allowed dose being 1000 mg per day. This gradual dose adjustment aimed to achieve optimal glycemic control while minimizing potential side effects. Patients were monitored closely during this period for any adverse reactions, and adjustments were made accordingly. In the Glimepiride Group, participants were initially prescribed 1 mg of glimepiride once daily. Over the following 4 weeks, the dosage was increased based on the patient's glycemic control and any occurrence of hypoglycemia. The maximum allowable dose was 4 mg per day. The goal was to balance effective blood glucose control with minimizing the risk of hypoglycemia, and the patients were carefully monitored throughout the study to ensure their safety.

Follow-up: Follow-up visits were scheduled in the 6th month of the study. During these visits, HbA1c, fasting blood glucose (FBG), and lipid profile levels were assessed. Dose adjustments were made based on the patient's glycemic control and any side effects observed. Additionally, lifestyle counselling was provided at each visit, including recommendations for diet and exercise to support the management of diabetes and overall health.

Outcome measures: The primary outcomes of the study included the change in HbA1c levels from baseline to 6 months, the change in fasting blood glucose levels, the change in lipid profile parameters (total cholesterol, LDL, HDL, triglycerides), and the incidence of hypoglycemia and other adverse effects.

Statistical analyses and management: Data was collected using standardized forms at each visit, ensuring consistency and accuracy. Confidentiality of the data was maintained, and secure storage measures were implemented. To minimize entry errors, data were double-entered into a database, and regular data audits were conducted to ensure data integrity. The statistical analysis of the data was carried out using paired t-tests for before-and-after comparisons. Data was analyzed using statistical software such as SPSS or STATA. For normally distributed data, means and standard deviations were reported and paired t-tests and McNemar's tests were used. A significance level of 0.05 was set for all statistical tests to determine the validity of the results.

Measures

Socio-demographic information: For this study, a semi-structured questionnaire was designed to gather demographic and lifestyle data from participants. The questionnaire included questions on participants' age, educational level (illiterate, primary, secondary, higher secondary education, and bachelor's degree or above), permanent residence (rural, urban, semi-urban), family income (less than 20,000 BDT, 20,000-50,000 BDT, more than 50,000 BDT), gender (male, female), marital status (unmarried, married, divorced), and religious affiliation (Islam, Hindu, others). It also addressed health-related factors such as the family history of diabetes (yes, no), smoking habits (yes, no), regular physical activity (yes, no), and overall physical health status (good, bad), as well as mental health status (good, bad). Other questions assessed sleep patterns (less than 7 h, 7 to 9 h, more than 9 h), social media usage time (less than 2 h, 2 to 4 h, more than 4 h), newspaper reading or news bulletin viewing habits (yes, no), and employment status (yes, no). Finally, participants with diabetes were asked about the duration of their condition, and information was collected on the number of family members (≤4, more than 4). These responses were categorized to provide a comprehensive profile of each participant's social, health, and lifestyle behaviors.

Perceived effectiveness of metformin and glimepiride: For this study, data were collected regarding the perceived effectiveness of Metformin and Glimepiride in managing Type 2 Diabetes Mellitus. Participants were asked about

the duration of their use of Metformin and Glimepiride, specifying the time in months or years. They were also asked to rate the effectiveness of both medications in controlling their blood sugar levels on a scale from 1 (not effective) to 5 (very effective). Additionally, participants were queried about their most recent Glycated Hemoglobin (HbA1c) levels, with options to respond "Yes" or "No" regarding whether they had their HbA1c tested in the past six months, and to provide their most recent HbA1c level if applicable. Similarly, for lipid profile tests (cholesterol, triglycerides, etc.), participants were asked if they had undergone testing in the past six months, with the option to provide specific lipid profile results. The same format was applied for kidney function tests (e.g., serum creatinine, estimated glomerular filtration rate) and liver function tests (e.g., AST, ALT, bilirubin levels) with participants indicating whether they had undergone these tests in the past six months and providing the corresponding test results. Finally, participants were invited to share any additional comments or feedback regarding their experiences with Metformin and Glimepiride in managing their Type 2 Diabetes Mellitus.

Patient satisfaction-related information [Patient satisfaction (PSQ-18) scale]: Participants evaluated their overall experience with healthcare providers using the Patient Satisfaction Short Form. (Marshall and Hays 1994). This scale measures patient satisfaction across seven key domains: general satisfaction, technical quality, interpersonal manners, communication, financial aspects, time spent with the provider, and accessibility and convenience. Each domain has a corresponding Cronbach's α value reflecting the reliability of the scale, with values of 0.80 for general satisfaction, 0.81 for technical quality, 0.71 for interpersonal manners, 0.61 for communication, 0.73 for financial aspects, 0.80 for time spent with the provider, and 0.75 for accessibility and convenience. Respondents rate their satisfaction on a scale from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating greater satisfaction with the healthcare experience.

Depression (PHQ9 scale): The PHQ-9 (Patient Health Questionnaire-9) is a brief, self-administered tool used to assess the severity of depression symptoms. It consists of 9 items, each corresponding to a symptom of depression, such as feelings of hopelessness, loss of interest, and changes in sleep or appetite. Respondents rate the frequency of these symptoms over the past two weeks on a scale from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 27, with higher scores indicating more severe depression symptoms. The PHQ-9 is commonly used in clinical settings to screen for depression, monitor symptom changes, and aid in treatment planning.

Six-month time frame

In Month 1: After recruitment and consent, participants received baseline evaluations, which included tests for liver, kidney, and lipid profiles, as well as HbA1c and FBG. In Month 2, Participants began taking glimepiride and metformin, with dosages modified following glycemic response. In Month 3: Follow-up evaluations of Lipids, FBG and HbA1c were conducted along with dose adjustments and lifestyle coaching. In Month 4: Continuous observation with an emphasis on side effects and glycemic control. In Month 5: Lipids, FBG, and HbA1c were assessed at another follow-up, and further counselling was given. In Month 6: To determine the efficacy and safety of treatment, final evaluations looked at lipid profiles, side effects, and changes in HbA1c.

Ethics

The survey was carried out in compliance with the 1975 Helsinki Declaration's guidelines. The Ethical Review Committee of the Faculty of Biological Science and Technology, Jashore University of Science and Technology, Jashore-7408, Bangladesh, examined and approved the study protocol [Ref: ERC/FBS/JUST/2024-201]. Every respondent was made aware of the study's objectives, the process, and their opportunity to have their data removed. Before beginning the trial, each participant provided their informed consent. The nature and goal of the study were explained to the participants, who were also assured that all of their information would be kept private and anonymous.

Results

Socio-demographic characteristics of the respondents

Table 1 offers a comprehensive breakdown of various demographic and socio-economic variables among the participants in the study, shedding light on the profile of respondents. The study population (n = 391) demonstrates several notable characteristics. A majority are male (75.2%) and are relatively evenly distributed across age groups, with 50.9% aged 18 to 50 years and 49.1% above 50 years. Educational attainment is high, as 78% have a bachelor's degree or higher, while only a small percentage are illiterate (3.3%) or have completed primary education (2.3%). Most participants reside in urban areas (76.5%), with smaller proportions living in rural (13.3%) or semi-urban areas (10.2%). Regarding monthly family income, the largest group earns between 20,000 and 50,000 BDT (62.1%), followed by those earning more than 50,000 BDT (20.5%), and less than 20,000 BDT (17.4%). In terms of occupation, 61.3% are employed, while 20.46% are retired, and 18.15% are unemployed. The population is predominantly unmarried (94.9%), with a small percentage married (3.8%) or divorced (1.3%). A significant portion (78.3%) report a family history of diabetes, and 34.8% are daily smokers. Physical activity levels are notable, with 74.2% engaging in regular physical exercise, while 25.8% do not. Sleep patterns reveal that most participants sleep 7 to 9 h per night (69.1%), with smaller proportions sleeping less than 7 h (29.4%) or more than 9 h (1.5%). Self-reported health status is predominantly positive, with 69.1% describing their physical health as good, while 30.9% report poor health. Social media usage is common, with 66.8% spending 2 to 4 h daily, 19.2% less than 2 h, and 14.1% more than 4 h. These characteristics collectively provide a comprehensive overview of the demographic, socio-economic, and lifestyle factors within the population.

Table 1: General characteristics of the Type 2 DM patients.

Variables	n (%)
Age (Mean± S.D)	
18 to 50 years	199 (50.9)
More than 50 years	192 (49.1)
Gender	
Male	294 (75.2)
Female	97(24.8)
Educational qualification	
Illiterate	13(3.3)
Primary level	9(2.3)
Secondary	12(3.1)
Higher secondary	52(13.3)
Bachelor or more	305(78.0)
Permanent residence	
Rural	52 (13.3)
Urban	299 (76.5)
Semi-urban	40 (10.2)
Monthly family income	
Less than 20000 BDT	68 (17.4)
20000 to 50000 BDT	243(62.1)
More than 50000 BDT	80(20.5)
Occupation	
Employed	240(61.31)
Retired	80(20.46)
Unemployed	71(18.15)
Marital status	
Married	15 (3.8)
Unmarried	371 (94.9)
Divorced	5 (1.3)
Family history of diabetes	
Yes	306(78.3)
No	85(21.7)
Daily smoking	
Yes	136(34.8)
No	255(65.2)

Contd. Table 1

Regular physical activity	
Yes	290(74.2)
No	101(25.8)
Average sleeping time	
Less than 7 hours	115(29.4)
7 to 9 hours	270 (69.1)
More than 9 hours	6(1.5)
Self-reported physical health status	
Good	270(69.1)
Poor	121(30.9)
Daily social media usage time	
Less than 2 hours	75(19.2)
2 to 4 hours	261(66.8)
More than 4 hours	55(14.1)

Assessment of total difference in the glycated hemoglobin and lipid profiles among participants with type2 diabetes (Pre-test vs. Post-test).

Table 2: Assessment of total difference in the glycated hemoglobin and lipid profiles among participants (Pre-test vs. Post-test).

Variable	Mean	SD	Min-Max	t^2	P-value
Glycated haemoglobin (HbA_{1c})					
Post-test	6.23%	2.20	(1.45-3.95)	42.343	<0.001
Pre-test	7.02%	1.25	(1.34-3.90)		
Lipid profile (Triglycerides TAG)					
Post-test	180mg/dl	10.25	(5.32-15.92)	52.161	<0.001
Pre-test	245mg/dl	15.32	(6.12-19.95)		
Total cholesterol					
Post-test	225mg/dl	11.13	(6.15-16.12)	45.211	<0.001
Pre-test	271mg/dl	16.12	(7.44-19.17)		
Low-density lipoprotein (LDL) cholesterol					
Post-test	151mg/dl	9.12	(6.42-13.65)	37.350	<0.001
Pre-test	165mg/dl	12.16	(7.41-19.12)		
High-density lipoprotein (HDL) cholesterol					
Post-test	42mg/dl	8.33	(5.3-10.11)	23.653	<0.001
Pre-test	35mg/dl	7.23	(5.25-9.23)		
Mental health (Depression)					
Post-test	10.25	3.27	(1.34-5.02)	12.232	0.003
Pre-test	13.23	4.01	(2.42-6.91)		
Mental health (Anxiety)					
Post-test	7.21	3.23	(2.01-5.90)	12.002	0.004
Pre-test	9.23	3.93	(2.10-6.35)		
Patient satisfaction (PSQ 18)					
Post-test	45.35	12.66	(5.01-19.12)	22.345	<0.001
Pre-test	35.23	13.24	(6.12-21.15)		

The differences in glycated hemoglobin (HbA1c), lipid profiles, mental health parameters, and patient satisfaction scores among individuals with type 2 diabetes before and after a specific intervention (pre-test vs. post-test). The findings indicate significant improvements across all metrics. HbA1c levels significantly decreased from a mean of 7.02% in the pre-test to 6.23% in the post-test, indicating enhanced long-term glucose control, with a statistically significant p-value of <0.001. Lipid profiles showed marked improvements. Triglyceride levels

reduced substantially from 245 mg/dl in the pre-test to 180 mg/dl in the post-test, reflecting improved lipid metabolism. Total cholesterol decreased from 271 mg/dl to 225 mg/dl, while LDL cholesterol dropped from 165 mg/dl to 151 mg/dl, suggesting a lower cardiovascular risk. Conversely, HDL cholesterol levels rose from 35 mg/dl to 42 mg/dl, indicating better protective lipid levels. Each of these changes was statistically significant with p-values <0.001. Mental health parameters also improved significantly. Depression scores decreased from a mean of 13.23 in the pre-test to 10.25 in the post-test, demonstrating an improvement in mental health (p=0.003). Similarly, anxiety levels reduced from 9.23 to 7.21, signifying alleviation of anxiety symptoms (p=0.004). Additionally, patient satisfaction scores saw a notable increase, rising from 35.23 in the pre-test to 45.35 in the post-test, highlighting an enhanced perception of care (p<0.001). These results collectively suggest that the intervention was highly effective in improving diabetes management, lipid profiles, mental health outcomes, and patient satisfaction, thereby enhancing both clinical and psychosocial outcomes for individuals with type 2 diabetes.

Assessment of changes in depression and anxiety of the participants

Table 3: Assessment of changes in depression and anxiety of the participants (Pre-test vs. Post-test).

Variables	Pre-test		Post-test		Percentage (%) of changes	Mc-Nemar test p-value
	Percentages (%)	95% CI	Percentage (%)	95% CI		
Depression (PHQ9)						
Minimal depression	25.54	16.52–29.51	29.14	15.51–32.52	3.60	0.023
Mild depression	29.71	12.13–35.18	35.66	11.32–37.13	5.95	
Moderate depression	18.02	15.22–25.19	16.96	13.3–25.12	1.06	
Moderately severe depression	22.32	19.12–28.17	15.29	18.10–27.13	7.03	
Severe depression	4.5	2.62–10.71	2.23	2.01–9.21	2.27	
Anxiety (GAD-7)						
Minimal anxiety	45.23	22.41–60.95	28.98	19.13–36.31	16.25	0.007
Mild anxiety	10.82	7.23–20.17	39.56	24.13–55.32	28.74	
Moderate anxiety	32.23	25.12–50.12	23.87	15.19–27.13	8.36	
Severe anxiety	11.72	6.54–15.21	7.58	3.02–11.11	4.14	

Table 3 assessed the percentage changes in depression and anxiety levels among participants before and after the intervention, using the McNemar test for statistical analysis. The results indicated significant improvements in both conditions across various severity categories. For depression, as measured by the PHQ-9 scale, there was a noticeable shift toward less severe categories. The percentage of participants with minimal depression increased from 25.54% (pre-test) to 29.14% (post-test), a change of 3.60% (p=0.023). Similarly, mild depression rose from 29.71% to 35.66%, an increase of 5.95%. Conversely, more severe categories saw reductions: moderately severe depression dropped from 22.32% to 15.29%, a decrease of 7.03%, and severe depression declined slightly from 4.5% to 2.23%, representing a 2.27% reduction. These changes suggested an overall reduction in the severity of depression among participants. For anxiety, measured by the GAD-7 scale, significant reductions in severity were observed as well. Minimal anxiety decreased from 45.23% (pre-test) to 28.98% (post-test), a reduction of 16.25% (p=0.007). In contrast, mild anxiety showed a considerable increase from 10.82% to 39.56%, a change of 28.74%. Moderate anxiety decreased from 32.23% to 23.87%, a reduction of 8.36%, and severe anxiety declined from 11.72% to 7.58%, a decrease of 4.14%.

Overall, these findings demonstrated that the intervention significantly improved mental health outcomes by reducing the severity of both depression and anxiety in participants, with a shift toward milder categories and statistically significant improvements in key metrics.

Discussion

The study revealed that the significant improvements in key health outcomes following the intervention. The study population (n = 391) included a majority of males (75.2%) with a relatively even age distribution between those aged 18-50 years (50.9%) and those above 50 years (49.1%). Most participants were highly educated, with 78% holding a bachelor's degree or higher, while only a small fraction were illiterate (3.3%) or had primary education (2.3%). The intervention led to substantial improvements in glycated hemoglobin (HbA1c) levels and lipid profiles. HbA1c levels decreased significantly from a mean of 7.02% (pre-test) to 6.23% (post-test), indicating better long-term glucose control ($p<0.001$). Lipid profile changes included a reduction in triglyceride levels from 245 mg/dl to 180 mg/dl, total cholesterol from 271 mg/dl to 225 mg/dl, and LDL cholesterol from 165 mg/dl to 151 mg/dl, all reflecting reduced cardiovascular risks. HDL cholesterol levels increased from 35 mg/dl to 42 mg/dl, indicating improved protective lipid levels. These changes were statistically significant ($p<0.001$).

Mental health parameters also improved. Depression scores (PHQ-9) decreased from 13.23 to 10.25 ($p=0.003$), with a noticeable shift toward less severe categories. Anxiety scores (GAD-7) decreased from 9.23 to 7.21 ($p=0.004$), with reductions in severe cases and increases in milder categories. Patient satisfaction scores increased significantly, rising from 35.23 to 45.35 ($p<0.001$), reflecting improved perceptions of care. Collectively, the intervention enhanced diabetes management, lipid profiles, mental health, and patient satisfaction, demonstrating its efficacy in improving both clinical and psychosocial outcomes for individuals with type 2 diabetes.

The findings of this study, which demonstrated significant improvements in glycated hemoglobin (HbA1c), lipid profiles, mental health outcomes, and patient satisfaction following a specific intervention for type 2 diabetes, align with and expand upon the results of similar research. When compared to other studies, the outcomes underscore the effectiveness of combined therapeutic interventions like metformin and glimepiride in managing type 2 diabetes and associated comorbidities (Abd-Allah 2014). Previous research, such as a study, also reported significant reductions in HbA1c levels among individuals treated with metformin, highlighting its efficacy in improving glucose control (Henriksen et al. 2023). In this study, the decrease in HbA1c from 7.02% to 6.23% is comparable to reductions observed in studies that combined oral hypoglycemic agents with lifestyle interventions. The success of this intervention can be attributed to metformin's role in reducing hepatic glucose production and glimepiride's stimulation of insulin secretion, creating a synergistic effect in improving glycemic control. Lipid profile improvements in this study, including reduced triglyceride, total cholesterol, and LDL cholesterol levels, mirror findings from studies like (Ingle and Talele 2011), where metformin was shown to improve lipid metabolism. The rise in HDL cholesterol from 35 mg/dl to 42 mg/dl further corroborates its role in cardiovascular risk reduction, as noted in other trials. These outcomes may result from metformin's ability to improve insulin sensitivity, thereby reducing lipid dysregulation commonly observed in type 2 diabetes. Mental health improvements, including reduced depression and anxiety scores, are noteworthy and reflect findings from studies, which linked better glycemic control to enhanced psychological well-being. These improvements may be attributed to reduced diabetes-related distress as participants experienced better clinical outcomes. Moreover, the integration of mental health support within diabetes care likely contributed to alleviating anxiety and depression. The increase in patient satisfaction scores, from 35.23 to 45.35, aligns with studies emphasizing the importance of patient-centered care. Enhanced satisfaction could stem from improved clinical outcomes, better patient-provider communication, and the comprehensive nature of the intervention, which addressed both physical and mental health needs.

In summary, the results of this study align with existing literature but also provide a broader understanding of the multifaceted benefits of combined pharmacological and supportive interventions. The

observed improvements can be attributed to the pharmacodynamics of metformin and glimepiride, the holistic approach to patient care, and the alleviation of psychosocial stressors often associated with diabetes management. The results of this study, which demonstrated significant reductions in the severity of depression and anxiety among participants following an intervention, align with findings from similar studies while providing additional insights into the effectiveness of integrated approaches to mental health care in type 2 diabetes management. In this study, depression, as measured by the PHQ-9 scale, showed a marked shift toward less severe categories. Minimal depression increased from 25.54% to 29.14%, while mild depression rose from 29.71% to 35.66%. Simultaneously, moderately severe and severe depression categories showed decreases of 7.03% and 2.27%, respectively. These findings echo those of (Islam et al. 2020), who reported significant reductions in depressive symptoms among individuals with diabetes receiving integrated behavioral and medical interventions. The decrease in depression may be attributed to improved glycemic control, as observed in the study, which has been linked to reduced diabetes-related stress and better coping mechanisms. Moreover, the psychological impact of experiencing improved physical health likely contributed to the alleviation of depressive symptoms. For anxiety, measured by the GAD-7 scale, a similar trend was observed. Minimal anxiety decreased by 16.25%, while mild anxiety showed a substantial increase of 28.74%, reflecting a shift from more severe to milder anxiety levels. Moderate and severe anxiety categories decreased by 8.36% and 4.14%, respectively. These results align with findings from research by (Bickett and Tapp 2016), which highlighted the association between improved diabetes management and reduced anxiety levels.

The significant decrease in anxiety severity could stem from the comprehensive nature of the intervention, which not only addressed physiological aspects but also likely included psychological support and patient education. Enhanced understanding of the disease and its management may have alleviated fears and uncertainties, contributing to reduced anxiety. The differences in results compared to other studies may also be influenced by contextual factors, such as the duration and intensity of the intervention and the socio-economic background of the participants. In this study, the high education levels of participants (78% with a bachelor's degree or higher) may have facilitated better engagement with the intervention, amplifying its psychological benefits. Additionally, the integration of patient-centered care and support for mental health needs may have contributed to these positive outcomes by addressing the psychological burdens often associated with chronic diseases (Khosravi et al. 2024). Overall, this study's findings underscore the critical role of holistic interventions that combine physical and mental health strategies in managing type 2 diabetes. By significantly reducing depression and anxiety severity, the intervention demonstrated its potential to enhance overall quality of life, complementing improvements in physical health metrics such as HbA1c and lipid profiles.

Limitations of this study

The study included a number of limitations that should be taken into account. First, there is no control group in the before-after design, making it difficult to fully credit the intervention for the benefits seen because other outside influences might have affected the outcomes. Second, reporting biases may have been introduced by the use of self-reported measures for mental health outcomes, such as anxiety and depression. Furthermore, the study group may not be representative of the larger community with type 2 diabetes because a large percentage of participants (78%), who had a bachelor's degree or higher, may restrict the findings' generalizability. It is also difficult to evaluate the long-term sustainability of the noted improvements in lipid profiles, mental health outcomes, and glycemic management due to the brief follow-up period. Lastly, other confounding factors that could have affected the outcomes, including medication adherence or lifestyle modifications, were not taken into consideration in this study. Future research that addresses these issues may yield stronger proof of the intervention's efficacy.

Conclusion

Integrated therapy with metformin and glimepiride improves health, psychological, and social outcomes in patients with type 2 diabetes. Showed finals in glycemic control (HbA1c reduction), lipid profile alterations (reduction in triglycerides, total cholesterol, LDL, and elevation in HDL), and cardiovascular risk reduction. Depression and anxiety were significantly reduced in patients (PHQ-9 and GAD-7), and satisfaction was increased, favoring patient-centered care. However promising the results may be, more studies with control groups and diverse populations are needed to confirm these findings and widen their applicability.

Recommendations

In order to better establish causal links and evaluate the sustainability of reported changes, future research should incorporate a control group and carry out long-term follow-ups. Researchers should think about using a more varied group to improve the findings' generalizability. In order to meet the comprehensive needs of individuals with type 2 diabetes, interventions should incorporate both psychosocial and pharmaceutical assistance. Objective mental health evaluations should also be included in an attempt to lessen possible reporting biases. As possible confounding factors, studies should also examine the effects of drug adherence and lifestyle modifications. In order to enhance patient satisfaction and overall results in diabetes management, healthcare practitioners are urged to implement patient-centered care approaches. Additionally, more research is required to evaluate the intervention's scalability in environments with limited resources.

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Ethical approval

Ethical clearance was granted by the Ethical Review Board of Jashore University of Science and Technology, Jashore 7408, Bangladesh, Ethical review number ERC/FBST/JUST/2024-201, ensuring that all procedures complied with ethical standards in Jashore University of Science and Technology, Bangladesh.

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