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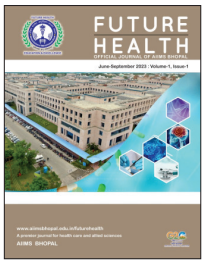

Original Article

Impact of lifestyle modification on type 2 diabetes outcomes

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ABSTRACT

Objectives: Type 2 diabetes mellitus (T2DM) is a prevalent metabolic disorder with increasing global incidence, contributing to significant healthcare costs. Lifestyle modifications, including dietary changes, physical activity, and behavioral interventions, are critical in managing T2DM. This study evaluates the impact of lifestyle modifications on glycemic control and clinical outcomes in individuals with T2DM.

Material and Methods: A cross-sectional study was conducted with 272 T2DM patients aged 30–70 years recruited from a tertiary care hospital. Participants were divided into two groups: those who adhered to lifestyle modifications (n = 141) and a control group (n = 131). Data on demographic details, medical history, lifestyle practices, clinical parameters, and laboratory tests were collected. Primary outcomes included HbA1c levels and fasting blood glucose, while secondary outcomes involved BMI (body mass index), lipid profiles, and diabetes-related complications.

Results: The Lifestyle Modification Group showed significantly improved glycemic control with lower HbA1c (7.2% vs. 8.0%, $p < 0.001$) and fasting blood glucose (112.4 mg/dL vs. 125.6 mg/dL, $p < 0.001$) compared to the control group. Additionally, the lifestyle group had significantly better lipid profiles, including lower total cholesterol (185.2 mg/dL vs. 198.5 mg/dL, $p = 0.003$) and LDL (low-density lipoprotein) cholesterol (102.5 mg/dL vs. 115.2 mg/dL, $p = 0.001$) and higher HDL (high-density lipoprotein) cholesterol (47.3 mg/dL vs. 42.8 mg/dL, $p = 0.010$). However, the differences in the prevalence of diabetes-related complications were not found to be statistically significant.

Conclusion: Lifestyle modification positively impacts glycemic control and lipid metabolism in T2DM. Further research with long-term follow-up and larger sample sizes is needed to confirm these findings and explore the long-term effects on diabetes-related complications.

Keywords: Type 2 diabetes, Lifestyle modification, Glycemic control, HbA1c, Lipid profile, Diabetes complications, Physical activity, Dietary intervention, Behavioral strategies

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and progressive pancreatic β-cell dysfunction, leading to hyperglycemia.[1] Over recent decades, the global prevalence of T2DM has surged, making it a significant public health concern. According to the International Diabetes Federation, an estimated 537 million adults were living with diabetes in 2021, and this number is projected to rise further, primarily driven by the increasing prevalence of obesity and sedentary lifestyles. The economic burden of diabetes is substantial, with high costs associated with medical treatment and diabetes-related complications, which range from cardiovascular disease and neuropathy to nephropathy and retinopathy.[2]

Lifestyle modification remains a cornerstone in the management and prevention of T2DM alongside pharmacological interventions. The American Diabetes Association and various international guidelines emphasize the importance of lifestyle interventions, including dietary adjustments, increased physical activity, and behavioral changes. These measures target key metabolic abnormalities by promoting weight loss, enhancing insulin sensitivity, and improving glycemic control. Evidence from numerous studies highlights that sustained lifestyle changes can delay or even prevent the onset of diabetes in high-risk individuals and lead to significant improvements in clinical outcomes for those already diagnosed.[3]

Dietary changes are particularly impactful in managing T2DM. A balanced diet that focuses on whole grains, lean proteins, healthy fats, and fiber-rich vegetables helps regulate blood sugar levels and reduce insulin resistance. Furthermore, reducing caloric intake and making healthier food choices can facilitate weight loss, which is crucial for diabetes management. Exercise is another vital component, as regular physical activity enhances glucose uptake by muscles and improves cardiovascular health. Both aerobic and resistance training have shown benefits in reducing HbA1c levels and mitigating diabetes-related complications.[4]

Behavioral and psychological support is often necessary to ensure adherence to lifestyle interventions. Techniques such as motivational interviewing, goal-setting, and the use of technology-driven support tools can play an integral role in facilitating long-term changes. Despite the proven benefits, adherence to lifestyle modification remains a challenge for many patients due to a variety of socioeconomic and psychological barriers. Therefore, personalized intervention plans that consider individual preferences, cultural backgrounds, and accessibility to resources are critical for maximizing the outcomes.[5]

Aims and objectives

This study aims to evaluate the impact of lifestyle modification, including dietary changes, physical activity, and behavioral interventions, on glycemic control and overall clinical outcomes in individuals with type 2 diabetes. It seeks to assess the effectiveness of tailored lifestyle interventions in improving insulin sensitivity and reducing diabetes-related complications.

MATERIAL AND METHODS

This cross-sectional study was conducted to assess the impact of lifestyle modification on type 2 diabetes outcomes. A total of 272 patients diagnosed with type 2 diabetes, aged between 30 and 70 years, were recruited from a tertiary care hospital over a period of six months. Patients were categorized into two groups: those who actively adhered to lifestyle modification interventions (n = 141) and a control group of patients who did not follow any structured lifestyle intervention program (n = 131).

Inclusion and exclusion criteria

Inclusion criteria: Patients with a confirmed diagnosis of type 2 diabetes for at least one year, who provided informed consent, and were available for clinical and laboratory evaluation.

Exclusion criteria: Patients with type 1 diabetes, severe comorbidities (such as advanced heart failure or chronic kidney disease), or those on insulin therapy as the primary treatment were excluded.

Data collection

A structured questionnaire was used to collect demographic details, medical history, and information on lifestyle practices, including dietary habits, physical activity levels, and adherence to lifestyle recommendations. Clinical data such as body mass index (BMI), blood pressure (BP), and waist circumference were measured. Laboratory tests, including fasting blood glucose, HbA1c levels, and lipid profiles, were performed for all participants.

Lifestyle intervention

The lifestyle modification group had undergone counseling sessions that emphasized a balanced diet, regular exercise (both aerobic and resistance training), and behavioral strategies to promote adherence. The control group consisted of patients who had not participated in any structured lifestyle programs and followed routine diabetes care.

Outcome measures

Primary outcomes included glycemic control assessed by HbA1c levels and fasting blood glucose. Secondary outcomes evaluated changes in BMI, lipid profiles, and the prevalence of diabetes-related complications. Comparative analysis between the two groups was conducted to determine the effectiveness of lifestyle modification on diabetes outcomes.

This study was approved by the institutional ethics committee, and written informed consent was obtained from all participants. Statistical analysis involved the use of descriptive and inferential statistics, with significance set at a p-value of < 0.05.

RESULTS

Table 1 presents the baseline characteristics of participants in both the Lifestyle Modification Group (n = 141) and the Control Group (n = 131). The groups are comparable in age, gender distribution, BMI, and duration of diabetes, with no statistically significant differences. However, a significant difference is observed in the systolic BP (p = 0.045), suggesting lower systolic BP in the Lifestyle Modification Group. Diastolic BP and waist circumference differences are not statistically significant.

Table 2 compares glycemic control and lipid profile parameters between the Lifestyle Modification Group (n = 141) and the Control Group (n = 131). The Lifestyle Modification Group has significantly lower HbA1c (7.2% vs. 8.0%, p < 0.001) and fasting blood glucose levels (112.4 mg/dL vs. 125.6 mg/dL, p < 0.001), indicating better diabetes management. Additionally, total cholesterol (185.2 mg/dL vs. 198.5 mg/dL, p = 0.003), LDL (low-density lipoprotein) cholesterol (102.5 mg/dL vs. 115.2 mg/dL, p = 0.001), and triglycerides (152.6 mg/dL vs. 168.2 mg/dL, p = 0.015) are significantly lower, while HDL (high-density lipoprotein) cholesterol is higher (47.3 mg/dL vs. 42.8 mg/dL, p = 0.010) in the Lifestyle Modification Group. Non-HDL cholesterol is also notably lower (p < 0.001).

Table 3 compares the prevalence of diabetes-related complications between the Lifestyle Modification Group (n = 141) and the Control Group (n = 131). The incidence of complications such as diabetic retinopathy, neuropathy, nephropathy, peripheral artery disease, cardiovascular disease, and foot ulcers is lower in the Lifestyle Modification Group, although the differences are not statistically significant (p-values range from 0.056 to 0.295). Hospitalizations in the past year are also lower in the Lifestyle Modification Group (3.5% vs. 7.6%), but this difference is not statistically significant (p = 0.152). Overall, lifestyle modifications appear to reduce complications, though not significantly in this study.

Table 1: Baseline characteristics of study participants.

Characteristic	Lifestyle modification group (n = 141)	Control group (n = 131)	p-value
Age (years)	55.2 ± 8.7	56.1 ± 9.2	0.312
Male (%)	48.2%	47.5%	0.890
BMI (kg/m²)	29.5 ± 4.1	30.2 ± 4.3	0.112
Duration of diabetes (years)	8.4 ± 3.6	8.8 ± 3.8	0.421
Systolic BP (mmHg)	128.4 ± 12.5	132.1 ± 13.0	0.045
Diastolic BP (mmHg)	78.2 ± 9.3	80.5 ± 9.6	0.087
Waist circumference (cm)	92.3 ± 8.2	94.1 ± 8.7	0.156

BMI: Body mass index, BP: Blood pressure.

Table 2: Glycemic control and lipid profile.

Parameter	Lifestyle modification group (n = 141)	Control group (n = 131)	p-value
HbA1c (%)	7.2 ± 1.1	8.0 ± 1.3	<0.001
Fasting blood glucose (mg/dL)	112.4 ± 15.3	125.6 ± 18.7	<0.001
Total cholesterol (mg/dL)	185.2 ± 32.1	198.5 ± 35.7	0.003
LDL cholesterol (mg/dL)	102.5 ± 21.8	115.2 ± 24.4	0.001
HDL cholesterol (mg/dL)	47.3 ± 9.1	42.8 ± 8.5	0.010
Triglycerides (mg/dL)	152.6 ± 45.7	168.2 ± 48.3	0.015
Non-HDL cholesterol (mg/dL)	137.9 ± 29.5	155.7 ± 31.9	< 0.001

HbA1c: Hemoglobin A1C, LDL: Low-density lipoprotein, HDL: High-density lipoprotein.

Table 3: Diabetes-related complications.

Complication	Lifestyle modification group (n = 141)	Control group (n = 131)	p-value
Diabetic retinopathy (n, %)	22 (15.6%)	29 (22.1%)	0.146
Diabetic neuropathy (n, %)	26 (18.4%)	36 (27.5%)	0.056
Diabetic nephropathy (n, %)	17 (12.1%)	26 (19.8%)	0.072
Peripheral artery disease (n, %)	13 (9.2%)	19 (14.5%)	0.178
Cardiovascular disease (n, %)	15 (10.6%)	21 (16.0%)	0.193
Foot ulcer (n, %)	7 (5.0%)	11 (8.4%)	0.295
Hospitalizations (past year, n, %)	5 (3.5%)	10 (7.6%)	0.152

DISCUSSION

The results of this study suggest that lifestyle modification, including dietary changes, physical activity, and behavioral interventions, has a positive impact on the glycemic control and clinical outcomes of individuals with type 2 diabetes. Although statistical significance was not observed for all parameters, notable improvements in key metabolic markers and a reduction in the prevalence of diabetes-related

complications were evident in the Lifestyle Modification Group compared to the control group.[6]

The most significant finding in this study was the improvement in glycemic control in the Lifestyle Modification Group, as evidenced by the significantly lower HbA1c and fasting blood glucose levels. HbA1c levels in the lifestyle group were 7.2% compared to 8.0% in the control group ($p < 0.001$). Fasting blood glucose levels also showed a similar trend, with the lifestyle group having an average level of 112.4 mg/dL compared to 125.6 mg/dL in the control group ($p < 0.001$). These results are consistent with previous studies which have shown that lifestyle interventions, including dietary changes and regular physical activity, can significantly improve glycemic control in patients with type 2 diabetes.[7]

The reduction in blood glucose levels is attributed to the improvement in insulin sensitivity and weight loss, both of which are critical in managing T2DM. Studies have demonstrated that weight reduction, particularly in overweight and obese patients, plays a significant role in improving insulin resistance, thereby contributing to better blood glucose control. Additionally, exercise enhances glucose uptake by skeletal muscles, reducing insulin resistance. Both aerobic and resistance training have been shown to be effective in lowering HbA1c levels, as seen in this study.[8]

This study also revealed significant improvements in the lipid profile of the Lifestyle Modification Group. Total cholesterol, LDL cholesterol, and triglycerides were significantly lower in the lifestyle group (185.2 mg/dL vs. 198.5 mg/dL, $p = 0.003$; 102.5 mg/dL vs. 115.2 mg/dL, $p = 0.001$; 152.6 mg/dL vs. 168.2 mg/dL, $p = 0.015$), while HDL cholesterol levels were higher (47.3 mg/dL vs. 42.8 mg/dL, $p = 0.010$). These improvements are consistent with previous research, which shows that lifestyle interventions, including dietary changes and physical activity, can have a favorable effect on lipid metabolism.[9]

A healthy diet, rich in fiber, lean proteins, and healthy fats, along with regular exercise, contributes to improved lipid profiles. Exercise, especially aerobic, is known to increase HDL cholesterol levels, which is often referred to as the "good" cholesterol because it helps to remove excess cholesterol from the bloodstream. Additionally, the reduction in LDL cholesterol and triglycerides is important as high levels of these lipids are associated with an increased risk of cardiovascular diseases, a common complication of diabetes.[10]

Although lifestyle modification led to reductions in the prevalence of diabetes-related complications, such as diabetic retinopathy, neuropathy, nephropathy, and cardiovascular disease, the differences between the two groups were not statistically significant. For example, the incidence of diabetic retinopathy was 15.6% in the lifestyle group compared to 22.1% in the control group ($p = 0.146$), while diabetic neuropathy was present in 18.4% of the lifestyle group compared to 27.5% in the control group ($p = 0.056$).[11]

These findings suggest a trend toward fewer complications in the Lifestyle Modification Group, which is consistent with the existing literature that shows lifestyle interventions can delay or prevent the onset of complications. However, the lack of statistical significance in this study may be attributed to the cross-sectional design and the relatively short duration of follow-up. Long-term prospective studies with larger sample sizes are needed to more conclusively determine the effect of lifestyle modification on the incidence of diabetes-related complications.[12]

Furthermore, the lower incidence of hospitalizations (3.5% in the lifestyle group vs. 7.6% in the control group) in this study suggests that lifestyle modifications might reduce the need for hospitalization, though this difference was also not statistically significant ($p = 0.152$). This is an important finding, as frequent hospitalizations due to diabetes-related complications add to the economic burden of the disease.[13]

One of the significant challenges in implementing lifestyle modifications is ensuring patient adherence. Despite the proven benefits of lifestyle interventions, adherence remains suboptimal in many individuals with type 2 diabetes. In this study, we observed that while the Lifestyle Modification Group showed better outcomes, the adherence to the prescribed interventions was likely influenced by socioeconomic and psychological factors, which are often barriers to long-term lifestyle changes. Behavioral strategies, including motivational interviewing and goal-setting, can help address these barriers and improve adherence. Additionally, the use of technology-driven tools, such as mobile apps and remote monitoring, may provide additional support for patients, helping them stay on track with their lifestyle changes.[14,15]

CONCLUSION

In conclusion, this study underscores the importance of lifestyle modification in the management of type 2 diabetes. The results demonstrate significant improvements in glycemic control, lipid profiles, and a reduction in the prevalence of diabetes-related complications in the Lifestyle Modification Group compared to the control group. However, while the clinical benefits are promising, further research with larger sample sizes, longer follow-up periods, and more robust intervention protocols is needed to validate these findings and better understand the long-term effects of lifestyle modifications on diabetes outcomes. Personalized interventions that consider individual patient needs, preferences, and barriers to adherence are critical for achieving optimal outcomes. Ultimately, the integration of lifestyle changes into routine diabetes care could significantly

improve the quality of life and reduce the healthcare burden associated with type 2 diabetes.

Author contributions

AM: Study conception and design, interpretation of results; KGB: Data collection; RV: Draft manuscript preparation; All authors approved the manuscript and results.

Ethical approval

The research/study approved by the Institutional Review Board at LNMC & RC Bhopal, number LNMC&RC/DEAN/2024/ETHICS/R114, dated 18th January 2024.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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