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Original Research Article

Lifestyle Medication to Manage Type 2 Diabetes and Its Impact on Biochemical Parameters

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ABSTRACT

Insulin resistance and high blood sugar are hallmarks of type 2 diabetes mellitus, a common chronic illness that has a substantial influence on world health. In order to avoid problems like cardiovascular disease and neuropathy, adequate care is essential. Pharmacological therapies are frequently used in traditional diabetes treatment. However, lifestyle improvements, including dietary adjustments, exercise, and stress reduction, have become essential elements of diabetic care. In order to improve glycemic control in individuals with type 2 diabetes, this study compares the efficacy of lifestyle medicine and standard therapy. In Punjab, Pakistan, a randomized controlled trial (RCT) was carried out in the cities of Kahuta and Faisalabad. One hundred volunteers, all between the ages of 35 and 50, who had been diagnosed as having type 2 diabetes and had HbA1c levels ≥6.5%, participated in the study. Participants were randomized to either Group B, which received regular medical care, or Group A, which received lifestyle interventions. Dietary changes, exercise routines, stress management strategies, and adherence counselling were the main focuses of the lifestyle intervention. To improve glycemic control, the seeds of chia and melon, especially bitter melon, were important dietary components. SPSS version 26 was used to analyze the data. Both groups showed significant improvements, according to within-group analysis (p-value <0.001). When compared to standard medical care, between-group analysis demonstrated the effectiveness of lifestyle interventions in controlling several health indices in diabetes patients, especially fasting blood glucose, cholesterol, CRP, BMI, and waist measurement (p-value <0.001). However, several variables, such as blood pressure, did not exhibit significant changes (p-value >0.05). The study concluded that intensive lifestyle changes can lead to meaningful improvements in metabolic health outcomes for individuals with type 2 diabetes, aligning with broader research advocating for such approaches as foundational components of diabetes care strategies.

1. Introduction

A primary global public health concern at the moment is the rise of diabetes mellitus (DM), a lifestyle disease that is becoming more and more common and a silent killer. The World Health Organization (WHO) defines diabetes as a metabolic disease with numerous etiologies that is characterized by persistently high blood sugar levels and disruptions in the metabolism of carbohydrates, fats, and proteins due to deficiencies in either the production or action of insulin, or both (Misra & Misra, 2020). This is a metabolic disorder that is spreading across the world at an alarming rate. It is brought on by autoimmune injury to the pancreatic beta cells, which prevents the generation of insulin. IDDM is another name for insulin-dependent diabetes mellitus. This kind of diabetes mellitus is common in youngsters and accounts for 5–10% of all cases of diabetes. Since type 2 diabetes mellitus (T2DM) accounts for over 90% of all occurrences of diabetes worldwide, it is the most prevalent form of the disease. This condition prevents glucose from entering the cell due to either insufficient insulin or desensitization of insulin receptors (Seiglie et al., 2020).

Worldwide, the incidence and prevalence of type 2 diabetes are rising more quickly. Globally, more than 425 million people were diagnosed with diabetes in 2017. By 2045, this figure could increase to 629 million individuals. According to a recent study, there are 463 million people with diabetes worldwide, representing a 9.3% prevalence rate. This prevalence rate is expected to increase to 10.2% by 2030 and 11.9% by 2045 (Abdul Basith Khan et al., 2020).

Type 2 diabetes (DM), a metabolic disorder, is becoming much more common worldwide. In 1980, 4.7% of adults over the age of 18 worldwide had type II diabetes. By 2014, that percentage had risen to 8.5 percent, and the total number of people with DM had quadrupled from 188 million in 1990 to 422 million in 2014. Patients with hypertension and diabetic comorbidities, especially chronic renal disease, have the highest mortality rates, while older, more obese people have the highest occurrences of diabetes (Adnan & Aasim, 2020). In the past, diabetes was thought to be a condition that mainly afflicted the wealthy and was most common in cities. However, sedentary lifestyles, dietary changes, and urbanization have cast doubt on this notion. Approximately 80% of T2DM cases currently occur in low- or middle-income nations, and forecasts suggest that these areas will continue to see the most significant increases in the following decades (Tinajero & Malik, 2021).

By computing local diabetic prevalence rates for several countries, the countries with the highest percentages of people with diabetes in 2019 were identified. China has the highest percentage of diabetic patients of any of these nations, with an estimated 116 million people living with the disease. It is estimated that the high-end diabetes groups consist of about 12 million people in Mexico, 16 million in Brazil, and 19 million in Pakistan (Lawrence et al., 2021).

People's weight growth and increasingly unhealthy lifestyles have contributed to the global diabetes epidemic, which is a major problem for the general public. Diabetes has significant economic consequences in addition to being a public health issue. In particular, the persistent problems with diabetes, along with the availability of contemporary pharmaceutical treatment options, are the leading causes of the rising costs of diabetes treatment (Tomic et al., 2022). Up to 88 million Americans suffer from prediabetes, and there are currently about 34 million identified and undiagnosed cases in the country. The annual cost of diabetes in the United States is projected to be $327 billion, of which $237 billion is spent on primary healthcare and $90 billion is attributed to lost productivity (Jarrar et al., 2023).

In addition to severe and incapacitating health implications, T2DM frequently leads to early mortality and decreased work productivity. The pathophysiology of type 2 diabetes is complex. Three main pathways lead to elevated glucose levels. Insulin resistance results in decreased peripheral glucose utilization in muscles, adipose tissue, and the liver (Diawara et al., 2023). Hyperglycemia is caused by the release of excess liver sugar as a result of pancreatic islet failure, which correlates with poor beta-cell insulin production and the secretion of excess glucagon by alpha-cells. Additionally, lower insulin production is associated with decreased peripheral glucose uptake. Over time, glucotoxicity, cellular oxidation damage, and inflammatory responses exacerbate beta-cell dysfunction and insulin resistance, making the situation worse (Tomic et al., 2024).

2. Materials and methods

2.1. Study design

A randomized controlled study (RCT), which is regarded as the gold standard for assessing the efficacy of therapies, was used in this investigation. The groups getting lifestyle treatments and those receiving standard medical care can be directly compared thanks to this design. By reducing confounding and bias variables, the RCT methodology offers solid proof of how well lifestyle modification can manage diabetes (Muthukumaraswamy et al., 2021).

2.2. Study population

The study was carried out in Pakistan at the Tehsil Headquarters (THQ) in Kahuta and Faisalabad. The current study sought to significantly improve health outcomes for people with diabetes by comprehending the extent of the issue, identifying risk factors, assessing healthcare responses, and guiding public health initiatives. The study selected participants who fit into the following categories: (1) Be between the ages of 35 and 50; (2) Be male or female; (3) Report having been diagnosed with type 2 diabetes; (4) Have a Hba1c score $\geq 6.5\%$; (5) Be fully prepared to comply with all study measures; (6) Be accessible during the study period; and (7) Be able to comprehend and be willing to sign the consent paper. Those with (1) Type 1 diabetes, an ischemic cardiovascular event within the previous six months, stage 3b or higher of chronic renal failure, (2) pregnancy, (3) a mental illness diagnosis, (4) severe arthritis that prevented walking, and (5) refusal to give consent were not allowed to participate in the study (Taheri et al., 2020). Using Epitool, a sample size of around 100 was determined (Ahmad et al., 2022)[(2)]

2.3. Intervention

Randomly chosen participants were divided into two groups: Group A received a lifestyle medication program, while Group B received standard diabetic medications.

2.3.1 Lifestyle Intervention

The 12-week lifestyle improvement program included six individual counseling sessions. Topics including dietary changes, increased physical activity, stress-reduction strategies, counselling to help stop smoking, and treatment plan adherence were discussed in these sessions. Four natural supplements were included in the diets of the diabetic patients to improve their general health. Because chia seeds are high in fiber and omega-3 fatty acids, which can help control blood sugar levels, they were advised to be eaten every morning (Okonta et al., 2014).

Melon seeds, which offer extra nutrients and possible advantages for metabolic health, were recommended for evening ingestion. Corosolic acid, found in the banaba plant, has insulin-like properties and helps control blood sugar. It is taken in the afternoon, twice a week. Finally, it has been demonstrated that bitter melon seeds, which are also eaten twice a week in the afternoon, increase glucose tolerance and decrease blood sugar levels. This combo encourages a comprehensive strategy for managing diabetes by changing one's lifestyle. Participants were instructed to consume bitter melons (Pot et al., 2020).

The following aerobic exercises (walking, jogging, and cycling) were to be performed by the participants. 40%–59% of heart rate reserve (HRR) or a rate of perceived exertion (RPE) of 11–12 is considered moderate intensity, whereas 60%–89% of HRR or RPE of 14–17 is considered vigorous intensity. They were instructed to aim for 75 to 150 minutes of strenuous activity each week, or to collect at least 150 to 300 minutes of moderate activity per week. They were asked to avoid more than two consecutive days without exercise between bouts, and there was a 5-minute warm-up and cool-down during the workout (Saeed et al., 2021).

Before working out, the blood glucose level was examined to make sure it was stable. As part of the mindfulness meditation program, participants were then instructed to find a comfortable position and unwind for approximately five minutes. All participants sat in their designated seats with a flat foot on the floor and a neutral lumbar position. For added support behind their backs and beneath their hips, they were told to sit up straight and use a pillow. At every follow-up session, the participants were instructed to concentrate on their breathing skills. The mindfulness meditation sessions lasted 10 minutes and took place twice a day, three to seven days a week (Kanaley et al., 2022).

2.3.2 Control group

Participants in the control group received usual medical diabetes care according to clinical guidelines. Metformin, if not contraindicated and if tolerated, is the preferred initial pharmacologic agent for the treatment of type 2 diabetes. Insulin therapy (with or without additional agents) was given to patients with newly diagnosed type 2 diabetes (Campione et al., 2022).

2.4. Statistical analysis

The study's outcome variables included weight (kg), height (cm), BMI (kg/m^2), waist circumference (cm), systolic blood pressure (mmHg), diastolic blood pressure (mmHg), fasting Glucose (mmol/L), postprandial glucose levels, total Cholesterol (mmol/L), Hb1Ac and CRP

2.4.1 Anthropometric measurements

Anthropometric measurements, including body weight (kg), BMI, and waist circumference (cm) (tape), were taken. Weight measurement was done by using a calibrated scale before and after. It was ensured that the person was wearing minimal clothing and had removed shoes for accuracy (Awasthi et al., 2017). Height measurement was done by utilizing a measuring tape. The individual was asked to stand straight against a wall with heels together, back straight, and looking forward. Then the height in meters (m) was recorded. BMI was calculated by dividing weight (kg) by height squared (m^2), and was categorized based on standard classifications: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (≥30) (Hukportie et al., 2021).

The waist circumference was calculated. The individual was asked to stand upright and breathe normally. It was ensured that they were wearing fitted clothing or no clothing around the waist for accurate measurement. The top of the iliac crest (the bony part of the hip) and the lowest rib on the side of the body were located and then measured around the abdomen at a point midway between these two landmarks, ensuring that the tape was parallel to the floor. Measurements in centimetres (cm) were recorded. Blood pressure was assessed twice on each occasion (baseline and end of study) at 5-minute intervals using a sphygmomanometer (Saberi-Karimian et al., 2023).

2.4.2 Biochemical profiles analysis

Blood tests were used to measure the subjects' HbA1c, fasting blood sugar, postprandial glucose levels, Total Cholesterol (mmol/L), and CRP before and after the treatment program. To reduce the chance of bias, the lab tests and measurements for the intervention group and the control group were done on different days (Mathew & Tadi, 2020).

For Hb1Ac analysis, a venous blood sample was collected, typically in an EDTA tube. No fasting was required, and samples were taken at any time. High-Performance Liquid Chromatography (HPLC) was used to analyze it. HPLC separates different haemoglobin fractions based on their ionic interactions with a resin in a column (Kumar & Agarwal, 2022). The blood sample was hemolyzed to release haemoglobin. The sample was injected into the HPLC system, where it passed through a TSK gel G8 column. Haemoglobin fractions were separated according to their charge and size. A photometer measured absorbance changes at 415 nm as fractions eluted. The area under the curve for HbA1c was compared to total haemoglobin to calculate the percentage of HbA1c. Results are typically expressed as a percentage (% HbA1c), reflecting average blood glucose levels over the past 2-3 months. Normal values are generally below 5.7%, while levels above 6.5% indicate diabetes (Adil & Ismail, 2024).

2.5. Data Collection Procedure

Data from people who met the inclusion criteria were gathered and used to evaluate the proposed research model with associated hypotheses. After receiving approval from the research and ethics commission, the research was started. After receiving informed consent, the treatment regimen guidelines were distributed to participants. Subsequently, demographic data about their subjective characteristics were taken at the start of the treatment plan. Biochemical analysis was conducted on participants before the treatment regimen began. Both the intervention and control groups received the treatment protocol. A second biochemical analysis was performed at the end of the treatment regimen. Outcomes were measured at the first treatment session (Pre-treatment) and immediately after the last treatment session (post-treatment). After that, the data was analysed (Dagliati et al., 2014).

2.6. Ethical considerations

Ethical approval is crucial for any research project that involves human subjects. Therefore, before the study could begin, it was necessary to obtain ethical approval from the ethics committee panel at Riphah International University in Faisalabad. Every individual who took part in the study was required to sign a written informed consent form that guaranteed the confidentiality of their data. Additionally, authorization from the research setup was obtained (Ellulu & Samouda, 2022).

2.7. Data Analysis Procedure

SPSS version 25 was used to examine the data. The data's normality was assessed using the Kolmogorov-Smirnov test. The demographic data was described using descriptive statistics. Frequencies and percentages were used to evaluate the categorical variables, while means and standard deviations were used to examine the continuous variables. An independent sample t-test was applied to find the difference in continuous variables between groups. A paired t-test was applied to find the difference in outcome measures within the groups. At $P=0.05$, the significance level was determined. The data were divided into two groups: Lifestyle medication programs were given to Group A, whereas usual diabetic medicines were given to Group B (Hussein et al., 2022).

3. Results and discussion

3.1. Demographic data of diabetic patients

Diabetes mellitus is a significant global health issue. Therefore, the sample population in the current study consisted of 100 diabetic patients who were treated with lifestyle medicine or usual medical care in the district and tehsil headquarter hospitals of Kahuta and Faisalabad city. First of all, on their first visit to the hospital, demographic data were taken from the patients, whose details are given below (Yu et al., 2024).

Table 1 shows that the mean age of diabetic patients in the current study is 47.78±7.585 years. Research indicates that the average age of diagnosis is often around 61.7 years. The average height is 166.11±6.678 cm, which is relatively consistent with global averages for adult males and females, but may vary by region. Weight is 74.06±8.130 kg, translating to a Body Mass Index (BMI) of approximately 26.8 kg/m2, which categorises individuals as overweight according to WHO classifications. Studies often report higher BMIs among diabetic patients, with many cohorts showing an average BMI above 30 kg/m^2, indicating obesity. For instance, a systematic review might show that around 49.3% of diabetic patients have a BMI ≥25 kg/m², suggesting a higher prevalence of obesity in the general diabetic population (Radzevičienė & Ostrauskas, 2013).

Current findings suggest that while patients in this study are overweight, they may not be classified as obese compared to other studies. This could indicate potential differences in lifestyle factors such as diet and physical activity levels among the participants. While the mean waist circumference is 124.34±15.930 cm, which is indicative of abdominal obesity, in the current study, waist circumference suggests a significant risk for complications associated with diabetes, such as cardiovascular disease and metabolic syndrome (Boye et al., 2021).

Table 1: Descriptive statistics for age, height, weight and waist circumference

	N	Mean	Std. Deviation
Age	100	47.78	7.585
Height	100	166.11	6.678
Weight	100	74.06	8.130
Waist circumference	100	124.34	15.930

Table 2 shows that in the current study, 60% males and 40% females were included. The male predominance (60%) in the study aligns with findings from various studies that report higher diabetes prevalence among men compared to women. This trend may be attributed to lifestyle factors such as dietary habits and physical activity levels, which often differ by gender. Men often exhibit riskier health behaviours and may be less likely to seek preventive care, leading to higher rates of undiagnosed diabetes (Al-Mukhtar et al., 2012)

Table 2: Gender distribution in groups

Gender	Frequency N	Percent %
Male	60	60
Female	40	40

Table 3 shows that the majority of diabetic patients in the current study reside in rural areas (59%) as opposed to urban areas (41%). Due to a lack of access to healthcare facilities, a lack of knowledge about managing diabetes, and lifestyle variables including nutrition and physical activity, studies show that the rate of diabetes is frequently greater in rural areas (Landgraf et al., 2022).

Table 3: Regional distribution of participants in groups

Region	Percent %
Rural	59.0
Urban	41.0

39% of patients were uneducated, 37% completed matriculation, 10% completed intermediate, 6% completed a bachelor's degree, 35% completed a master's degree, and 5% earned an MPhil degree (Table 4). The study's large proportion of uneducated patients (39%) is in line with research showing a link between diabetes prevalence and lower educational levels. According to studies, people with lower levels of education frequently have less health literacy and are less knowledgeable about diabetes care techniques. On the other hand, improved self-management practices and treatment regimen adherence are linked to higher educational attainment (Coppola et al., 2016).

Table 4: Education level of patients in the groups

Education level	Percent %
Uneducated	39.0
Matric	37.0
Intermediate	10.0
Bachelors	6.0
Masters	3.0
MPhil	5.0

Table 5 reveals that 40% of patients work in the private sector, 32% of female patients are housewives, 21% their own business, and 7% are engaged in the public sector. According to the study's employment distribution, a sizable percentage of patients (40%) are employed in the private sector. The type of employment might have an impact on health outcomes. Additionally, because of their domestic duties, women may face particular difficulties in treating diabetes (Almeida et al., 2011).

Table 5: Occupation of patients in the groups

Occupation	Percent %
Housewife	32
Public sector job	7
Private sector job	40
Self-employed	21

According to Table 6, 63 per cent of patients smoke, 25 per cent do not smoke, 8 per cent stop, and 4 per cent are passive smokers. According to some studies, smoking raises the risk of type 2 diabetes considerably and worsens the difficulties faced by diabetic patients (Durlach et al., 2022).

Table 6: Smoking status of patients in the groups

Smoking status	Percent %
Smoker	63.0
Non-Smoker	25.0
Passive Smoker	4.0
Quitter	8.0

Table 7 reveals that 51% of patients have had diabetes for 1-5 years, 36% for 6–10 years, and 13% for 11–15 years. According to research, early diagnosis within the first five years is essential for managing conditions effectively and lowering long-term problems (Ahmad et al., 2022).

Table 7: History of diabetes among patients in the groups

History of diabetes	Percent %
1-5 years	51.0
6-10 years	36.0
11-15 years	13.0

According to Table 8, 30% of patients have a family history of diabetes. One known risk factor for type 2 diabetes is family history. According to research, inheritance and similar environmental factors put those with a family history at a higher risk (Hu et al., 2021).

Table 8: Family history of diabetes among patients in the groups

Family history of diabetes	Percent %
Yes	30.0
No	70.0

According to Table 9, 25% of individuals have high blood pressure, and 75% do not. The study shows rates among diabetic groups range from 37.4% to 80%. According to the literature, the prevalence of hypertension is greatly influenced by variables like age, obesity, and lifestyle (Przezak et al., 2022).

Table 9: High blood pressure among patients in the groups

High blood pressure	Percent %
Yes	25.0
No	75.0

According to Table 10, ischemic heart disease affects 19% of patients, chronic lung disease affects 12%, chronic kidney disease affects 10%, and chronic vascular disease affects 1% of patients. Patients with diabetes frequently suffer from comorbid conditions, including cardiovascular disease (Younis et al., 2022).

Table 10: Any disease other than diabetes among patients in the groups

Any other disease	Percent %
None	58.0
Chronic kidney disease	10.0
Chronic lung disease	12.0
Ischemic heart disease	19.0
Chronic vascular disease	1.0

Table 11 reveals that 36% of patients are non-adherent, 18% have neutral adherence habits, and 46% are slightly non-adherent to therapy or medication. According to research, adherence rates are highly influenced by variables like socioeconomic status, education level, and support networks (Udupa et al., 2023).

Table 11: Adherence to treatment/medication among patients

Adherence to treatment	Percent %
Non-Adherent	36.0
Partially non-Adherent	46.0
Neutral	18.0

According to Table 12, 47% of patients have the poorest quality of life as a result of diabetes, while 53% of patients have a poor quality of life. Diabetes significantly impacts quality of life due to its chronic nature and associated complications. Research indicates that lower quality of life scores are associated with poorer glycemic management. The high percentage of patients in the current study who reported having a low quality of life emphasizes the necessity of comprehensive strategies that consider both medical care and psychological assistance (Yu et al., 2024). Normal distribution of data

Table 12: Quality of life among patients between the groups

Quality of life	Percent %
Worst	47.0
Poor	53.0

The average distribution of the data was evaluated in order to apply statistics to the gathered data using the normality test (Campbell et al., 2020).

A substantial p-value (>0.05) indicates that the data is usually distributed, according to the results for the test of normality, which are displayed in Table 13 (Sampson et al., 2018).

Table 13: Test of normality

Variables	Kolmogorov-Smirnov		
	Statistic	**df**	**Sig.**
Pre HbA1c	0.109	100	0.214
pre-fasting blood glucose	0.121	100	0.285
Pre- and postprandial glucose levels	0.101	100	0.413
Pre-systolic BP	0.105	100	0.306
Pre diastolic BP	0.131	100	0.270
Pre total cholesterol	0.108	100	0.366

df: degrees of freedom; Sig: Significance

3.2. Results of parametric tests

The use of parametric tests evaluated the normal distribution of data. To determine whether the initial and final values of outcomes differ within groups, the paired sample t-test is utilized. The t-test for independent samples is used to determine differences between groups. The outcomes are displayed below (Wu et al., 2020)

Table 14 reveals that the pre-HbA1c mean in group A decreased from 10.60±2.07 to the post-HbA1c mean of 7.82±1.57, with a p-value <0.001. According to a randomized controlled experiment, individuals who made significant lifestyle modifications experienced an average 1%–2% decrease in HbA1c over a year, which is consistent with the outcomes observed in Group A. With a p-value <0.001, the pre-HbA1c mean of group B was decreased from 10.99±.2.09 to the post-HbA1c mean of 8.16±1.46. Although regular medical care in Group B significantly decreased HbA1c, the effect was not as pronounced as that observed with lifestyle modification. The results indicate that HbA1c levels decreased across all weeks in both therapy groups. However, the reduction was more substantial in Group A than in Group B (Taylor et al., 2021)

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Table 14: Comparison of mean Hb1Ac scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre HbA1c	10.60±2.07	<0.001	Pre HbA1c	10.99±.2.09	<0.001
Post HbA1c	7.82±1.57		Post HbA1c	8.16±1.46	

The pre-fasting blood glucose mean in group A dropped from 363.24±61.14 to the post-fasting blood glucose mean of 195.40±23.05, with a p value <0.001, according to Table 15 data. Intensive lifestyle modification programs often lead to reductions in fasting blood glucose levels comparable to those obtained from pharmaceutical treatments. According to a study that was published in the New England Journal of Medicine, lifestyle modifications successfully lowered fasting plasma glucose levels, emphasizing the role that nutrition and exercise play in diabetes management (Hazuda et al., 2021). The pre-fasting blood glucose mean in group B dropped from 382.34±61.08 to 222.20±50.51 after fasting, with a p-value <0.001. While medications can reduce fasting blood glucose levels, studies suggest they often do not address the underlying causes of insulin resistance and may be less effective than lifestyle modifications in managing type 2 diabetes (Yang et al., 2022).

Table 15: Comparison of mean fasting blood glucose scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre-fasting blood glucose	363.24±61.14	<0.001	Pre-fasting blood glucose	382.34±61.08	<0.001
Post-fasting blood glucose	195.40±23.05		Post-fasting blood glucose	222.20±50.51	

The findings in Table 16 indicate that the mean pre-postprandial glucose levels in group A dropped from 9.54±1.23 to 6.94±.74, with a p-value <0.001. Lifestyle changes can lower postprandial hyperglycemia, which is important for controlling type 2 diabetes. It has been demonstrated that low-glycemic index food-focused interventions successfully lower postprandial glucose spikes, improving overall glycemic control. Improved insulin sensitivity and delayed stomach emptying are the mechanisms behind these gains. In group B, pre-postprandial glucose levels mean decreased from 9.77±1.27 to post-postprandial glucose levels mean 7.22±.82, with a p value <0.001. The reduction in Group B can be attributed primarily to pharmacological interventions that enhance insulin secretion or sensitivity (Dingena, 2023).

Table 16: Comparison of mean postprandial glucose levels in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre- and postprandial glucose levels	9.54±1.23	<0.001	Pre- and postprandial glucose levels	9.77±1.27	<0.001
Postprandial glucose levels	6.94±.74		Postprandial glucose levels	7.22±.82	

Table 17 results indicate that group A's pre-systolic blood pressure mean dropped from 129.00±17.64 to 120.60±7.11 with a p-value <0.001. The mean pre-diastolic blood pressure dropped from 86.70±15.17 to 82.60±4.43 with a p-value <0.001. In group B, pre-systolic BP mean decreased from 134.60±23.75 to post-systolic BP mean 123.20±11.50, with a p value <0.001. Pre-diastolic BP mean decreased from 89.00±16.13 to post-diastolic BP mean 82.40±5.91, with a p value <0.001. The reduction in BP in Group B can be attributed to antihypertensive medications that act through various mechanisms (Malakar et al., 2024). The results indicate that both treatment approaches led to significant improvements in both systolic and diastolic BP; however, the greater reductions observed in Group A emphasize the effectiveness of lifestyle interventions for patients with elevated blood pressure levels at baseline.

Table 17: Comparison of mean systolic/diastolic BP scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre systolic bp	129.00±17.64	<0.001	Pre systolic bp	134.60±23.75	<0.001
Post-systolic BP	120.60±7.11		Post-systolic BP	123.20±11.50	
Pre diastolic bp	86.70±15.17	<0.001	Pre diastolic bp	89.00±16.13	<0.001
Post diastolic bp	82.60±4.43		Post diastolic bp	82.40±5.91	

The results of Table 18 show that in group A, pre-total cholesterol mean decreased from 211.10±25.01 to post-total cholesterol mean 169.46±13.15, with a p value <0.001. For instance, the DASH (Dietary Approaches to Stop Hypertension) diet has been shown to reduce total cholesterol by an average of 10% to 15% in individuals with elevated levels, supporting the findings observed in Group A. In group B, pre-total cholesterol mean decreased from 219.90±25.90 to post-total cholesterol mean 179.96±16.35, with a p value <0.001 (Michalakis & Ilias, 2020)

Table 18: Comparison of mean total cholesterol scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre total cholesterol	211.10±25.01	<0.001	Pre total cholesterol	219.90±25.90	<0.001
Post total cholesterol	169.46±13.15		Post total cholesterol	179.96±16.35	

The results of Table 19 show that in group A, the pre-CRP mean decreased from 38.96±19.72 to the post-CRP mean of 18.96±9.93, with a p-value <0.001. A systematic review published in Diabetes Care found that lifestyle interventions, particularly those involving weight loss and increased physical activity, were effective. In group B, pre-CRP mean decreased from 54.04±17.15 to post-CRP mean 28.34±11.75, with a p value <0.001, showing improvement. The findings indicate that both treatment approaches led to significant improvements in CRP levels; however, the greater reduction observed in Group A emphasises the effectiveness of lifestyle interventions for patients with elevated baseline inflammation (Hejazi et al., 2023).

Table 19: Comparison of mean CRP scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre CRP	38.96±19.72	<0.001	Pre CRP	54.04±17.15	<0.001
Post CRP	18.96±9.93		Post CRP	28.34±11.75	

The results of Table 20 show that in group A, the pre-BMI mean decreased from 26.90±1.27 to the post-BMI mean of 23.28±1.40, with a p value <0.001. The Diabetes Prevention Program demonstrated that participants who engaged in intensive lifestyle interventions achieved an average weight loss of 5-7% of their body weight, which is associated with improved metabolic outcomes and reduced risk of developing type 2 diabetes. In group B, pre-BMI mean decreased from 26.66±1.79 to post-BMI mean 26.01±2.03, with a p value <0.001. Studies have shown that while some patients may experience minor weight loss through medical treatment or monitoring, the results are often less impactful than those achieved with comprehensive lifestyle changes (Rahimi et al., 2022).

Table 20: Comparison of mean BMI scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre BMI	26.90±1.27	<0.001	Pre BMI	26.66±1.79	<0.001
Post BMI	23.28±1.40		Post BMI	26.01±2.03	

The results of Table 21 show that in group A, the pre-waist circumference mean decreased from 88.30±8.42 to the post-waist circumference mean of 78.18±8.00, with a p-value <0.001. Regular exercise not only helps reduce overall body fat but also specifically targets visceral fat, which is associated with higher risks of cardiovascular disease and type 2 diabetes (Palu et al., 2022).

Table 21: Comparison of mean waist circumference scores in groups A and B

Variables of Group A	Mean±SD	P-value	Variables of Group B	Mean±SD	P-value
Pre waist circumference	88.30±8.42	<0.001	Pre waist circumference	94.10±9.21	<0.001
Post waist circumference	78.18±8.00		Post waist circumference	88.72±10.07	

The post mean value of variables of both groups was compared using an independent t-test. The mean value of post HbA1c of group A was 7.82±1.57, while the mean value of post HbA1c of group B was 8.18±1.46, with a mean difference of -0.35, with a p-value of >0.05, which showed no statistically significant difference over the three months between the two groups (Table 22). Both treatments improved Hb1Ac levels, but no treatment was superior to the other. Research consistently shows that lifestyle modifications can lower HbA1c levels significantly (Johansen et al., 2017).

Mean value of post fasting blood glucose of group A was 195.40±23.05, while mean value of post fasting blood glucose of group B was 222.20±50.51with a mean difference of -26. With a p-value of <0.005, which showed a statistically significant difference over the three months between the two groups. Regular physical activity enhances glucose uptake by muscle cells during and after exercise, reducing circulating blood glucose levels for up to 24 hours post-exercise due to increased insulin sensitivity. The Mean value of postprandial glucose levels of group A was 6.94±.74, while the mean value of post-HbA1c of group B was 7.22±.82 with a mean difference of -0.28 and a p-value of >0.05, which showed no statistically significant difference over the three months between the two (Papakonstantinou et al., 2022).

Table 22: Group comparison of post mean values of variables

Variables	Group	Mean	Std. Deviation	Mean Difference	P-value
Post HbA1c	A	7.82	1.57	-0.35	0.241
	B	8.18	1.46		
Post-fasting blood glucose	A	195.40	23.05	-26.80	0.001
	B	222.20	50.51		
Postprandial glucose levels	A	6.94	0.74	-0.28	0.076
	B	7.22	0.82		
Post-systolic BP	A	120.60	7.11	-2.60	0.177
	B	123.20	11.50		
Post diastolic BP	A	82.60	4.43	0.20	0.849
	B	82.40	5.91		
Post total cholesterol	A	169.46	13.15	-10.50	0.001
	B	179.96	16.35		
Post CRP	A	18.96	9.93	-9.38	0.000
	B	28.34	11.75		
Post BMI	A	23.28	1.40	-2.73	0.000
	B	26.01	2.03		
Post waist circumference	A	78.18	8.00	-10.54	0.000

The value of post-systolic BP of group A was 120.60±7.11, while the mean value of post-systolic BP of group B was 123.20±11.50, with a mean difference of -2.60, and a p-value of >0.05, which showed no statistically significant difference over the three months between the two groups. Mean value of post-diastolic BP of group A was 82.60 ± 4.43, while mean value of post-diastolic BP of group B was 82.40±5.91 with a mean difference of 0.20, with a p-value of >0.05, which showed no statistically significant difference over the three months between the two groups. Weight loss reduces vascular resistance and improves endothelial function, while physical activity promotes vasodilation and increases nitric oxide availability, leading to lower blood pressure.

The mean value of post waist circumference of group A was 78.18 ± 8.00, while the mean value of post waist circumference of group B was 88.72±10.07, with a mean difference of -10. A p-value of <0.001 was observed, indicating a significant difference between the two groups over the three months (Costanzo et al., 2023). Waist circumference is a critical measure for assessing abdominal obesity; reductions are often seen with effective lifestyle interventions. Reducing waist circumference decreases visceral fat accumulation, which is associated with insulin resistance and metabolic syndrome components. The mean post-BMI value for group A was 23.28±1.40, and for group B, it was 26.01±2.03, resulting in a mean difference of -2.73 (p-value < 0.001). This difference was observed over the three months between the two groups. Significant weight loss achieved through lifestyle interventions has been linked to improvements in metabolic health (Taylor, 2024)

4. Conclusion

Type 2 diabetes mellitus (T2DM) is a significant global health challenge, characterized by insulin resistance and chronic hyperglycemia. The condition poses severe risks of complications, including cardiovascular diseases, neuropathy, and kidney failure. Traditional management strategies primarily focus on pharmacological interventions; however, recent evidence suggests that lifestyle modifications such as dietary changes, increased physical activity, and stress management play a crucial role in diabetes care. This study aimed to compare the effectiveness of lifestyle intervention against usual care in managing blood sugar levels among type 2 diabetic patients. The research employed a randomized controlled trial (RCT) design, considered the gold standard for evaluating intervention effectiveness. Conducted in Kahuta and Faisalabad, Pakistan, the study recruited 100 participants aged 35 to 50 years who had been diagnosed with T2DM and exhibited HbA1c levels of ≥6.5%. Participants were selected using a simple random sampling technique to ensure fairness and minimize selection bias. Inclusion criteria included individuals aged 35-50 years, both male and female, with a confirmed diagnosis of T2DM. Exclusion criteria encompassed those with type 1 diabetes, recent ischemic cardiovascular events, pregnancy, mental illness, severe arthritis affecting mobility, or refusal to provide consent. Participants were randomly assigned to two groups: Group A received lifestyle interventions, while Group B received the standard medical care.

The lifestyle intervention program consisted of six one-on-one counselling sessions over 12 weeks. Participants were advised to incorporate natural supplements such as chia seeds, melon seeds, and bitter melon into their diets to enhance glycemic control. These foods are known for their beneficial effects on blood sugar regulation. Following the Physical Activity Guidelines for Americans, participants were instructed to engage in aerobic exercises—such as walking, jogging, or cycling—aiming for at least 150 to 300 minutes of moderate-intensity activity per week. Participants practised diaphragmatic breathing and mindfulness meditation during counselling sessions to help manage stress effectively. Participants in Group B received standard medical care according to clinical guidelines. This included adjustments to diabetes medications aimed at achieving individualized glycemic control. Metformin was the preferred initial pharmacologic agent unless contraindicated.

The study population consisted of 100 diabetic patients with a mean age of 47.78 years. The majority were male (60%), with a significant proportion living in rural areas (59%). A high percentage of participants had low educational attainment, which correlates with poorer health literacy and diabetes management awareness. Results indicated significant improvements in glycemic control in both groups. Although the control group also experienced reductions in blood glucose during fasting, the extent of improvement was less pronounced compared to those who adopted lifestyle modifications. This reduction is particularly relevant for preventing post-meal hyperglycemia, which can contribute to long-term complications associated with diabetes. Additionally, both groups showed improvements in blood pressure measurements, with the lifestyle intervention group achieving equally significant reductions in both systolic and diastolic blood pressure that were observed in the control group. This finding underscores the broader health benefits of lifestyle modifications or medications beyond glycemic control.

Declarations

Ethics approval and consent to participate

The ethical approval was obtained from ethical Committe of Riphah International University in Faisalabad, Pakistan. informed consent was also obtained from each individual involved in the study .

Ethical consideration

Not applicable.

Consent for publication

Not applicable.

Competing interests

Not applicable.

The authors declare that they have no competing interests

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Author's Contribution

Conceptualization, writing the original draft: Areej Fatima, Khalil u Rehman. Formal analysis, investigations, funding acquisition: Hamza Rafeeq, Nadia Afsheen, Zara Jabeen. Resources, project administration, reviewing and editing: Shamsa Kanwa, Farina Jamil, Muhammad Ejaz-ul-Haq, Shakila Sabir

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Data Availability

The data used in this study are included in the article.

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