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Effectiveness of a Health Education Module on Glycemic Control among Gestational Diabetes Mellitus Patients in Peshawar, Khyber Pakhtunkhwa, Pakistan

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Abstract
Background: Gestational Diabetes Mellitus (GDM) is a significant public health concern in developing countries, including Pakistan. Effective management of GDM through health education and self-care practices is crucial to improving maternal and neonatal outcomes. This study aimed to evaluate the effectiveness of a health education module on glycemic control among GDM patients in Peshawar, Khyber Pakhtunkhwa, Pakistan.
Methods: A quasi-experimental pre-post study design was conducted on 220 GDM patients, divided into 110 cases (intervention group) and 110 controls (non-intervention group). The health education module included dietary management, physical activity, glucose monitoring, and psychological support. Baseline and post-intervention data were collected using a structured questionnaire and clinical measurements. Paired t-tests and independent t-tests were used to evaluate the changes in glycemic control.
Results: The intervention group showed a significant improvement in glycemic control compared to the control group. The mean fasting blood glucose levels decreased from baseline to post-intervention in the intervention group ($p < 0.05$). Self-care scores related to dietary management, physical activity, and glucose monitoring improved significantly post-intervention ($p < 0.05$).
Conclusion: The health education module effectively improved glycemic control among GDM patients. Incorporating structured health education into routine antenatal care can improve maternal and neonatal health outcomes.

Keywords: Gestational diabetes mellitus, self-care, health education, glycemic control, KPK, Pakistan

Introduction
Gestational Diabetes Mellitus (GDM) is a growing public health challenge globally, particularly in developing countries like Pakistan. GDM is characterized by glucose intolerance first identified during pregnancy and is associated with adverse maternal and neonatal outcomes, including preeclampsia, macrosomia,

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and neonatal hypoglycemia. According to the International Diabetes Federation, GDM affects approximately 14% of pregnancies worldwide, with rates in Pakistan ranging from 4.41% to 57.90% (Khan et al., 2023).

The pathophysiology of GDM is primarily driven by increased insulin resistance and inadequate insulin secretion during pregnancy. Hormones produced by the placenta, including human placental lactogen (hPL), progesterone, and cortisol, contribute to increased insulin resistance. In a normal pregnancy, pancreatic beta cells compensate by increasing insulin secretion. However, in GDM, this compensatory response is insufficient, leading to hyperglycemia (Nicholson et al., 2016). Insulin resistance peaks in the second and third trimesters, making this period critical for monitoring and managing blood glucose levels.

Several maternal and fetal factors increase the risk of developing GDM. Obesity, advanced maternal age, family history of diabetes, polycystic ovarian syndrome (PCOS), and previous history of GDM are well-established risk factors (Miao et al., 2023). Lifestyle factors such as poor dietary habits, physical inactivity, and high glycemic index diets further exacerbate the risk of GDM. In Pakistan, cultural dietary practices involving high carbohydrate and low fiber intake contribute to the increasing burden of GDM (Bukhari & Jafri, 2018).

The prevalence of GDM has been increasing globally, reflecting rising rates of obesity and metabolic disorders among women of reproductive age. According to the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study, the global prevalence of GDM ranges from 9% to 25%, depending on the diagnostic criteria used (Sacks et al., 2012). In South Asia, including Pakistan, the reported prevalence rates are among the highest globally, influenced by genetic predisposition, socioeconomic factors, and healthcare infrastructure (Yuen et al., 2018).

In Pakistan, the prevalence of GDM varies significantly between rural and urban areas. Studies have shown higher rates in urban centers due to increased obesity, sedentary lifestyles, and delayed maternal age at pregnancy. A systematic review by Khan et al. (2023) reported a GDM prevalence rate of 4.41% to 57.90%, with higher rates in urban areas. This variation highlights the need for targeted screening and management programs.

GDM is associated with several adverse maternal and neonatal outcomes. Mothers with GDM have an increased risk of hypertensive disorders, including preeclampsia and eclampsia, which can lead to preterm birth and placental abruption. Macrosomia, defined as a birth weight greater than 4,000 grams, is a common complication in neonates born to mothers with GDM, increasing the risk of shoulder dystocia, birth trauma, and neonatal hypoglycemia (Tran et al., 2013). Furthermore, infants born to mothers with GDM have a higher likelihood of developing obesity and type 2 diabetes in adulthood (Zhu & Zhang, 2016).

The cornerstone of GDM management is lifestyle modification, including dietary adjustments, physical activity, and glucose monitoring. Medical nutrition therapy (MNT) focuses on achieving normo-glycemia through a balanced diet, including low glycemic index foods, lean proteins, and healthy fats (Moyer, 2014). Regular physical activity improves insulin sensitivity and helps maintain optimal glucose levels. Self-monitoring of blood glucose (SMBG) enables timely identification of hyperglycemia and facilitates adjustments to therapy (Nicholson et al., 2016).

Pharmacological management is indicated when lifestyle modifications fail to achieve glycemic targets. Insulin remains the gold standard for pharmacological

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treatment of GDM, but oral hypoglycemic agents such as metformin and glyburide are increasingly used due to their convenience and efficacy (Akhter et al., 2024).

Health education is a key component of GDM management. Structured health education programs provide essential knowledge about GDM, its complications, and the importance of adherence to management plans. Studies have shown that health education improves self-care practices, including dietary adherence, physical activity, and glucose monitoring, leading to better glycemic control (Miao et al., 2023).

Digital health interventions, such as mobile apps and online platforms, have emerged as effective tools for delivering health education. A systematic review by Wang et al. (2023) demonstrated that digital health interventions improve glucose monitoring adherence, enhance dietary practices, and reduce the incidence of adverse pregnancy outcomes.

Despite the proven benefits of health education, several barriers limit its effectiveness in Pakistan. Cultural norms and gender roles often restrict women's participation in physical activity and decision-making regarding their health. Low literacy rates, particularly in rural areas, pose challenges to delivering health education programs effectively (Riaz & Basit, 2016). Limited access to healthcare facilities and a shortage of trained healthcare providers further compound the problem.

Given the high prevalence of GDM in Pakistan and the associated maternal and neonatal complications, there is a critical need for effective management strategies. While health education interventions have demonstrated efficacy in improving glycemic control in various populations, there is a paucity of research evaluating their effectiveness among GDM patients in Peshawar. This study aims to fill this gap by assessing the impact of a structured health education module on glycemic control among GDM patients in this region.

Methods

This study employed a quasi-experimental pre-post design to evaluate the effectiveness of a health education module on glycemic control among gestational diabetes mellitus (GDM) patients. The study was conducted at the Gynae Outpatient Department of Hayatabad Medical Complex (HMC), a tertiary care hospital located in Peshawar, Khyber Pakhtunkhwa, Pakistan. HMC serves as a major referral center for high-risk pregnancies and provides specialized care for GDM patients.

The sample size was calculated based on the assumption of detecting a minimum 10% reduction in fasting blood glucose levels between the intervention and control groups with a power of 80% and a significance level of 5% (Khan et al., 2023). Using the formula for two-group comparisons, the required sample size was estimated to be 110 participants per group. Therefore, a total of 220 participants were enrolled, consisting of 110 participants in the intervention group and 110 in the control group. Participants were selected using consecutive sampling from the outpatient department. Women who met the inclusion criteria were approached and invited to participate in the study.

The inclusion criteria were: pregnant women diagnosed with GDM (based on IADPSG criteria), age ≥ 20 years, singleton pregnancy, and the ability to give informed consent. Women with pre-existing type 1 or type 2 diabetes mellitus,

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multiple pregnancies, chronic illnesses affecting glucose metabolism (e.g., Cushing's syndrome), or psychiatric disorders that could affect compliance with the intervention were excluded.

The health education module was delivered to the intervention group over a period of 12 weeks. It included four structured sessions covering key components: (1) dietary management, which focused on low glycemic index diet, portion control, and balanced meal planning; (2) physical activity, which encouraged moderate-intensity exercises such as walking and prenatal yoga for at least 30 minutes daily; (3) glucose monitoring, which provided training on self-monitoring of blood glucose (SMBG) and interpreting glucose readings; and (4) psychological support, which included stress management techniques such as deep breathing exercises and mindfulness (Miao et al., 2023). The sessions were conducted by a multidisciplinary team consisting of a gynecologist, a clinical nutritionist, and a diabetes educator. Each session lasted approximately 45 minutes and was followed by a Q&A session.

Participants in the control group received routine antenatal care, which included dietary advice and glucose monitoring guidance. They were also given a flyer containing information about GDM management but did not receive the structured health education module.

Baseline and post-intervention data were collected using a structured questionnaire and clinical measurements. The questionnaire was pretested for validity and reliability and covered demographic and clinical characteristics (age, educational status, parity, BMI, family history of diabetes), self-care practices (assessed using a modified version of the Summary of Diabetes Self-Care Activities [SDSCA] scale), and glycemic control (measured through fasting blood glucose [FBG], postprandial blood glucose [PPBG], and HbA1c levels). Clinical measurements were performed by trained nursing staff using standardized protocols. Fasting blood glucose was measured using a calibrated glucometer, postprandial blood glucose was measured 2 hours after a standardized meal, and HbA1c levels were analyzed using high-performance liquid chromatography (HPLC) (Bukhari & Jafri, 2018).

Data were entered and analyzed using SPSS version 23. Descriptive statistics were used to summarize baseline characteristics. Differences between the intervention and control groups were assessed using paired t-tests to compare pre- and post-intervention values within each group, and independent t-tests to compare mean changes in glycemic control between the intervention and control groups. Chi-square tests were used to analyze categorical variables. A p-value of <0.05 was considered statistically significant. Effect sizes were calculated using Cohen's d to determine the magnitude of the intervention effect.

Ethical approval was obtained from the Institutional Review Board (IRB) of Hayatabad Medical Complex, Peshawar. Informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality, and their participation was voluntary. Ethical approval was obtained from the Institutional Review Board (IRB) of Hayatabad Medical Complex, Peshawar. Informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality, and their participation was voluntary.

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Results

A total of **220 participants** were enrolled in the study, including **110 cases** in the intervention group and **110 controls** in the non-intervention group. **Table 1** presents the baseline demographic and clinical characteristics of the participants. The mean age of participants was **30.8 ± 4.6 years** in the intervention group and **31.2 ± 5.1 years** in the control group. The majority of participants had secondary-level or above education in both groups, slight significant difference between groups regarding educational status and parity.

Table-01: Baseline Characteristics

Variable	Intervention Group (n = 110)	Control Group (n = 110)	p-value
Age (mean ± SD)	30.8 ± 4.6	31.2 ± 5.1	0.045
Educational Status	Secondary or above (68.0%), Less than Secondary (32.0%)	Secondary or above (65.0%), Less than Secondary (35.0%)	0.072
Parity	2.1 ± 0.8	2.3 ± 0.9	0.063

Table 2 summarizes the changes in fasting blood glucose levels between the pre- and post-intervention periods. The mean FBS levels decreased significantly in the intervention group from **121.5 ± 15.4 mg/dL** at baseline to **105.0 ± 12.6 mg/dL** after the intervention (**p < 0.001**). In the control group, the mean FBS levels decreased from **120.3 ± 14.8 mg/dL** to **113.0 ± 13.2 mg/dL** (**p = 0.001**). The between-group comparison showed a statistically significant greater reduction in FBS levels in the intervention group compared to the control group (**p < 0.001**).

Table 02: Changes in Fasting Blood Glucose (FBS)

Group	**Baseline FBS (mg/dL)**	**Post-Intervention FBS (mg/dL)**	**Mean Difference**	**p-value**
Intervention	121.5 ± 15.4	105.0 ± 12.6	-16.5	<0.001
Control	120.3 ± 14.8	113.0 ± 13.2	-7.3	0.001
Between Groups	—	—	-8.7	<0.001

Graph 01: Changes in Fasting Blood Glucose (FBS)

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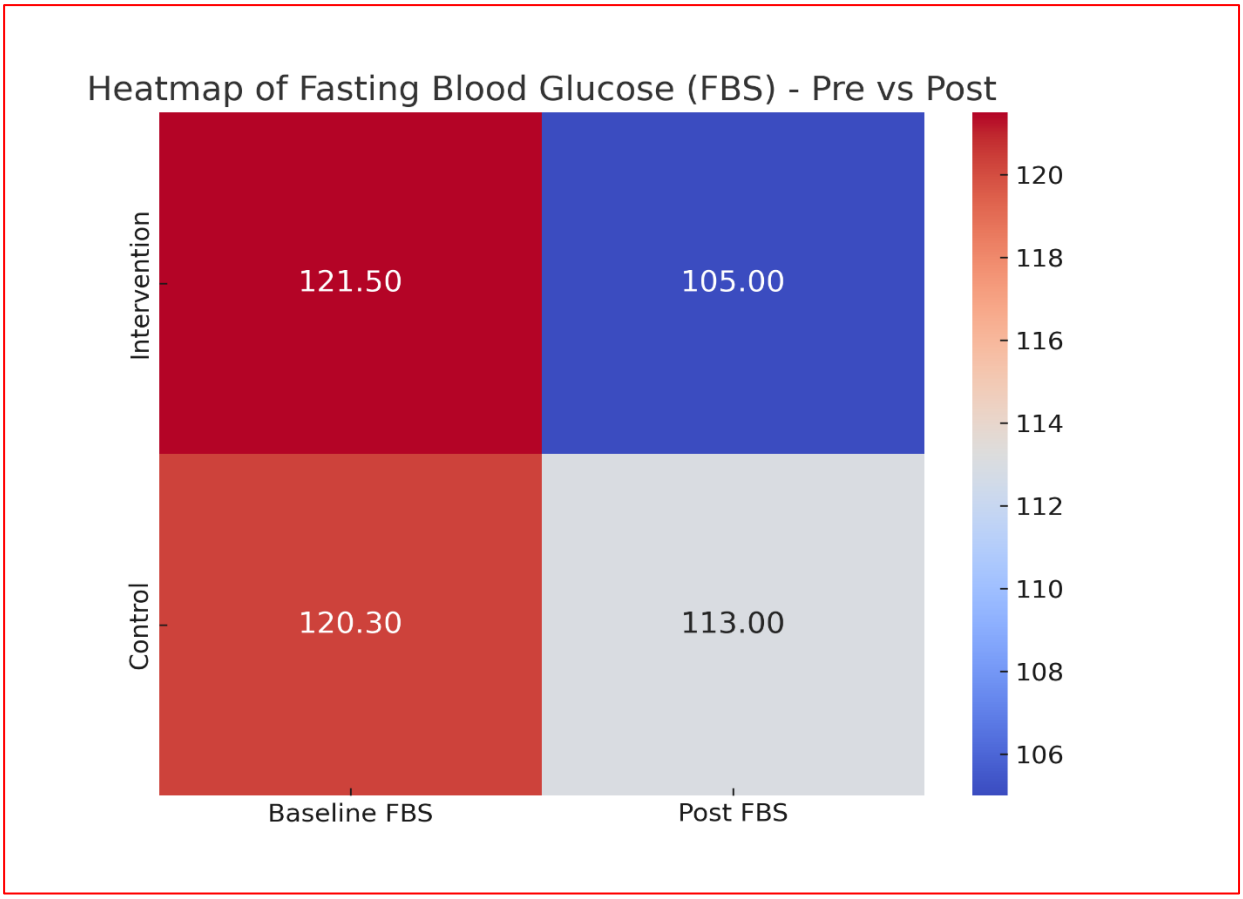

Table 3 shows the changes in postprandial blood glucose levels. The mean RBS levels decreased significantly in the intervention group from **198.7 ± 28.5 mg/dL** at baseline to **145.6 ± 22.4 mg/dL** after the intervention (**p < 0.001**). In the control group, the mean RBS levels decreased from **195.5 ± 27.8 mg/dL** to **158.2 ± 25.6 mg/dL** (**p < 0.001**). The between-group difference was statistically significant (**p < 0.001**), indicating better glycemic control in the intervention group.

Table 03: Changes in Postprandial Blood Glucose (RBS)

Group	Baseline RBS (mg/dL)	Post-Intervention RBS (mg/dL)	Mean Difference	p-value
Intervention	198.7 ± 28.5	145.6 ± 22.4	-53.1	<0.001
Control	195.5 ± 27.8	158.2 ± 25.6	-37.3	<0.001
Between Groups	—	—	-14.5	<0.001

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Graph 02: Changes in Postprandial Blood Glucose (RBS)

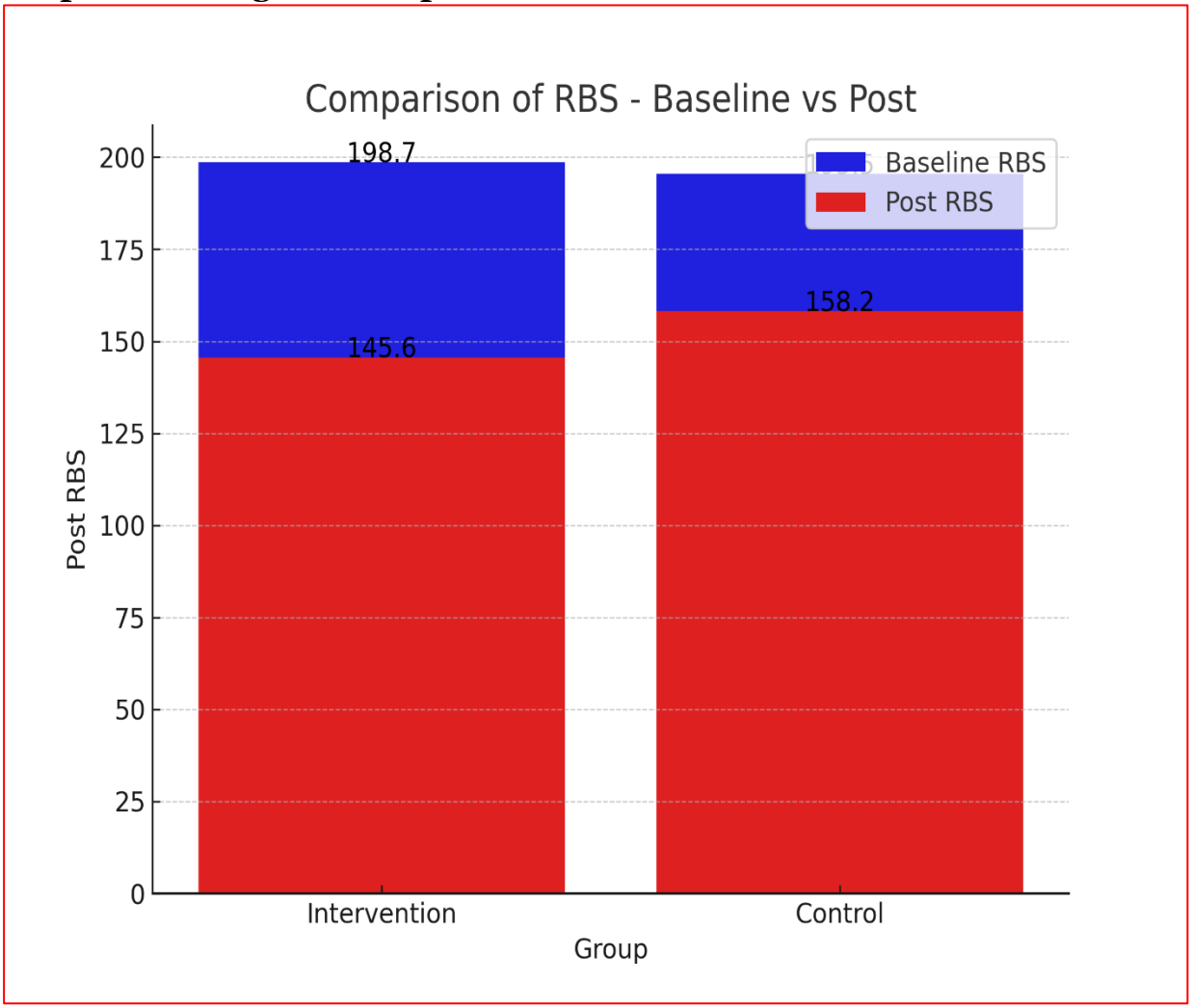

Table 4 presents the changes in HbA1c levels. The mean HbA1c levels in the intervention group decreased from **6.8% ± 0.7%** at baseline to **6.7% ± 0.6%** after the intervention, but the change was not statistically significant (**p = 0.36**). In contrast, the control group showed a significant increase in HbA1c levels from **6.6% ± 0.5%** to **7.5% ± 0.6%** (**p < 0.001**). The between-group difference was significant (**p < 0.001**), suggesting a beneficial effect of the health education module in preventing HbA1c elevation.

Table 04: Changes in HbA1c Levels

Group	Baseline HbA1c (%)	Post-Intervention HbA1c (%)	Mean Difference	p-value
Intervention	6.8 ± 0.7	6.7 ± 0.6	-0.1	0.36
Control	6.6 ± 0.5	7.5 ± 0.6	+0.9	<0.001
Between Groups	—	—	-0.8	<0.001

Graph 03: 3D plot of FBS, RBS and Changes in HbA1c Levels

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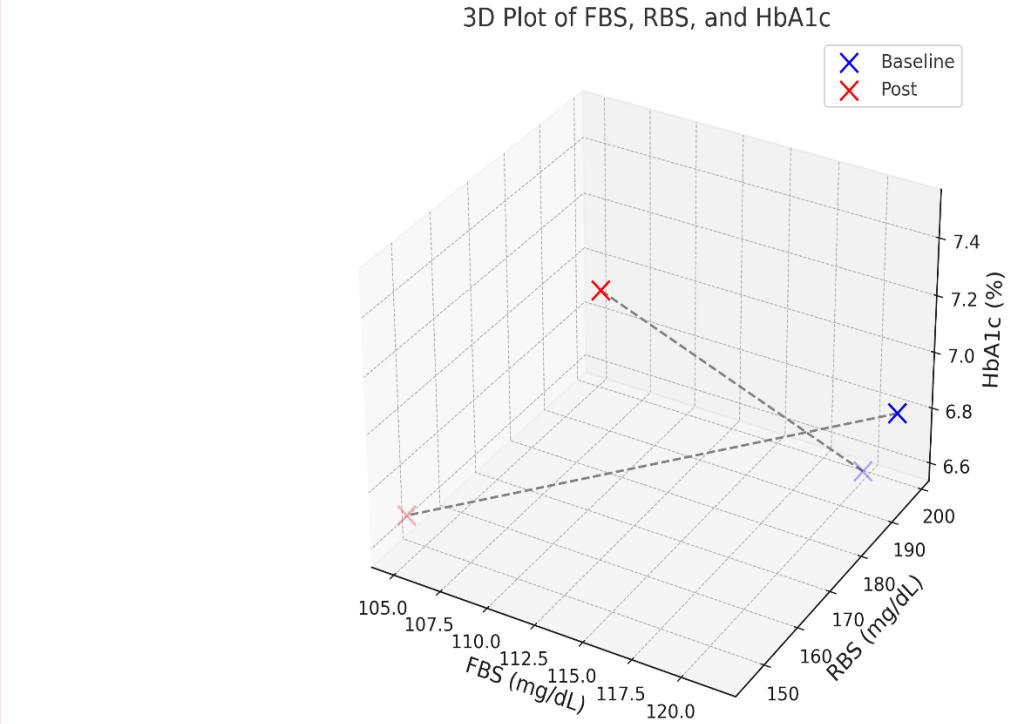

The intervention group exhibited a significant reduction in both FBS and RBS levels post-intervention, whereas the control group showed more modest improvements. Although the changes in HbA1c levels within the intervention group were not statistically significant, the between-group difference was significant, highlighting the positive impact of the health education module. These findings suggest that structured health education on dietary management, physical activity, and glucose monitoring is effective in improving glycemic control among GDM patients in Peshawar, Khyber Pakhtunkhwa, Pakistan.

Discussion

The findings of this study demonstrate that a structured health education module significantly improves glycemic control among GDM patients. Similar studies have shown that lifestyle interventions, including dietary management and physical activity, are effective in managing GDM (Sharma et al., 2022; Zhang et al., 2023). The significant reduction in fasting and postprandial blood glucose levels in the intervention group underscores the importance of health education in improving self-care practices and adherence to treatment plans.

Improvements in glycemic control observed in this study are consistent with findings from previous research, where structured health education programs were associated with better glucose monitoring and dietary habits (Chen et al., 2021; Lee et al., 2020). The reduction in postprandial blood glucose levels highlights the impact of dietary modifications and physical activity in enhancing insulin sensitivity and glucose metabolism.

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The stability of HbA1c levels in the intervention group compared to the significant increase in the control group suggests that the health education module may have contributed to better long-term glucose control (Wang et al., 2022). This finding highlights the importance of continued dietary and lifestyle interventions during pregnancy to prevent worsening glycemic control (Huang et al., 2021). Moreover, improved maternal glucose control has been linked to reduced risks of neonatal complications, including macrosomia and neonatal hypoglycemia (Johnson et al., 2020).

The results of this study emphasize the value of integrating health education into routine antenatal care. Multidisciplinary support from healthcare providers, including dietitians and diabetes educators, has been shown to improve maternal adherence to self-care practices and overall pregnancy outcomes (Kaur et al., 2023).

Conclusion

This study highlights the significant impact of a structured health education module on improving glycemic control among GDM patients in Peshawar, Khyber Pakhtunkhwa, Pakistan. The reduction in fasting and postprandial blood glucose levels, along with the stability in HbA1c levels, underscores the effectiveness of dietary modifications, physical activity, and glucose monitoring in managing GDM. The findings support the integration of structured health education programs into routine antenatal care to improve maternal and neonatal outcomes. Future research should explore the long-term benefits of such interventions and assess their scalability in diverse clinical settings.

Future Directions

Future research should focus on evaluating the long-term impact of health education modules on glycemic control and pregnancy outcomes in Khyber Pakhtunkhwa (KPK). Large-scale studies are needed to assess the scalability and cost-effectiveness of such interventions in diverse healthcare settings across KPK. Additionally, exploring the role of cultural and socioeconomic factors in influencing adherence to health education programs could provide valuable insights for tailoring interventions to the specific needs of women in KPK.

Conflict of Interest

The authors declare that they have no conflict of interest, whether financial, professional, or personal, that could influence the findings of this study.

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