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Assessment of Breakfast Quality Index (BQI), Glycemic Index, Glycemic Load in Individuals Diagnosed with Type 2 Diabetes Mellitus Aged Between 35-60 Years

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Abstract: India has seen an alarming rise in non-communicable diseases (NCDs), particularly type 2 diabetes mellitus (T2DM), driven by urbanization, dietary shifts, and sedentary lifestyles. While breakfast is often termed the "most important meal of the day," the quality of this meal especially in terms of glycemic index (GI) and glycemic load (GL) has not been sufficiently studied in the Indian diabetic population. This study explored whether the quality and glycemic characteristics of breakfast could influence glycaemic control among middle-aged adults with T2DM. The primary objective of this study was to evaluate the breakfast quality, glycemic index (GI), and glycemic load (GL) of breakfasts consumed by individuals diagnosed with type 2 diabetes mellitus (T2DM) aged between 35 and 60 years. Specifically, the study aimed to assess breakfast quality using the Breakfast Quality Index (BQI), determine the GI and GL of breakfast meals through 24-hour dietary recall and examine their associations with key glycaemic markers namely fasting blood glucose, postprandial blood glucose, and HbA1c levels. Additionally, the study sought to explore potential correlations between breakfast composition and biochemical parameters, with the broader goal of understanding how breakfast quality and glycemic characteristics impact glycaemic control in individuals living with T2DM. A cross-sectional study was conducted among 60 adults (30 males, 30 females) aged 35-60 years, diagnosed with T2DM for at least six months. Participants were recruited from a diabetes specialty clinic in Mumbai. Breakfast quality, GI, and GL were assessed through validated dietary assessment tools. Anthropometric and biochemical parameters were collected from clinic records. Statistical analysis involved ANOVA and Pearson's correlation using SPSS software. Participants were categorized based on glycaemic control: mildly elevated HbA1c (6.5-7%, n=19), moderately elevated (7.1-8%, n=26), and poorly controlled (8.1-9%, n=15). A progressive increase in mean weight and BMI was observed with worsening glycaemic control, though not statistically significant ($p > 0.05$). However, fasting glucose and postprandial levels were significantly higher in the poorly controlled group (165.00 ± 48.11 mg/dL and 250.00 ± 75.80 mg/dL, respectively; $p < 0.001$). Breakfast Quality Index showed a negative correlation with BMI ($r = -0.354$, $p = 0.005$), suggesting that better breakfast quality was linked with lower body weight. Though not statistically significant, higher BQI was also associated with lower fasting glucose ($r = -0.236$, $p = 0.071$) and postprandial glucose ($r = -0.228$, $p = 0.082$). Interestingly, BQI was positively correlated with GI and GL ($r = 0.318$ and $r = 0.320$ respectively, both $p = 0.013$), indicating that nutrient-dense breakfasts may still possess a high glycaemic impact depending on food composition. The findings suggest that breakfast quality, glycemic index, and glycemic load are important and interrelated dietary factors that may influence glycaemic outcomes in individuals with T2DM. While a higher BQI is linked to better metabolic profiles and lower BMI, it does not necessarily imply a lower glycaemic impact. This highlights the need for culturally tailored dietary guidelines that not only emphasize nutrient density but also carbohydrate quality for effective diabetes management in India.

Keywords: Breakfast, Breakfast Quality, Type 2 Diabetes Mellitus, Glycemic Control, Blood Glucose Levels, Glycemic Index, Glycemic Load

1. Introduction:

In 2021, NCDs were responsible for at least 43 million deaths, accounting for roughly 75% of all deaths not related to pandemics. Projections from the NCD Alliance indicate that, if current trends persist, annual deaths from NCDs could reach 52 million by 2030 (World Health Organization, 2024). Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion and insulin resistance. It is the most common form of diabetes, accounting for approximately 90% of all diabetes cases worldwide (Goyal R. et al. 2023). Diabetes illustrates this growing burden: its prevalence has climbed from 4.0% (135 million cases) in 1995 to an estimated 5.4% (300 million cases) by 2025, with about three-quarters of those affected living in developing countries highlighting the disproportionate impact on low and middle income regions

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(World Health Organization, 2024). As of 2023, approximately 101 million individuals in India are diagnosed with diabetes, with an additional 136 million at risk of developing the condition due to prediabetes. This represents a dramatic increase from earlier years; the prevalence rose from 7.1% in 2009 to 11.4% in 2023, illustrating a concerning upward trend in diabetes cases across the nation (Maniyara, K. et al., 2025). Epidemiology on type-2 diabetes in India identified that genetics, family history, age, ethnicity, unhealthy diet, physical inactivity, use of tobacco and alcohol, high body mass index, raised blood sugar, and blood lipid levels are major risk factors for diabetes (Pradeepa et al., 2021). Breakfast is referred to as the most important meal of the day due to its role in regulating metabolism, improving glycemic control, and supporting overall health (Li, Z. H., et al. 2021). Skipping breakfast has been linked to impaired glucose metabolism, increased insulin resistance, and higher fasting blood glucose levels (Ogata, H. et al., 2019). Regular breakfast consumption is associated with a lower risk of developing T2DM. Individuals who skip breakfast have a higher likelihood of experiencing adverse metabolic outcomes, including increased insulin resistance and elevated fasting glucose levels (Maki, K. C. et al. 2016). Breakfast consumption correlates with improved glucose and insulin responses throughout the day, which is critical for individuals managing diabetes (Maki, K. C. et al. 2016). The quality of breakfast plays a crucial role in regulating carbohydrate metabolism and supporting overall metabolic health. High-fiber breakfasts, particularly those based on whole grains or legumes, have been shown to improve glycemic control. Protein-rich breakfasts may displace glucose-generating carbohydrates, leading to lower glucose and insulin responses. The consumption of UFAs alongside proteins can further enhance these effects by improving lipid profiles and promoting satiety, which is essential for weight management an important consideration in T2D management (Maki, K. C. et al., 2016). Recent clinical and observational studies have shown that low-GI breakfasts resulted in significantly lower postprandial glucose levels in individuals with T2DM compared to high-GI breakfasts. Specifically, subjects who consumed low-GI options experienced reductions in blood glucose concentrations at 30, 60, and 120 minutes post-meal (Peres, M. et al., 2023). Despite these findings, limited data exist on the combined impact of BQI, GI, and GL on glycaemic outcomes within the Indian population. Moreover, few studies have examined how these breakfast components and quality relate to important biochemical markers especially in middle-aged adults, who represent a growing and vulnerable group for T2DM. This study aims to bridge that gap by evaluating the quality and glycemic characteristics of breakfast using BQI, GI, and GL among adults aged 35 to 60 years diagnosed with T2DM. By exploring how these factors relate to their glycaemic profiles, the research hopes to offer practical, evidence-based insights that can support culturally tailored dietary recommendations and preventive strategies suited to the Indian population. The aim of this study is to assess breakfast Quality Index (BQI), glycemic Index and glycemic load of breakfast in individuals diagnosed with type 2 diabetes mellitus aged 35 - 60 years.

2. Materials and Methodology

A cross-sectional observational study was conducted over a period of three months and aimed to assess the Breakfast Quality Index (BQI), glycemic index (GI), and glycemic load (GL) of breakfast meals, and their association with glycaemic markers in individuals diagnosed with type 2 diabetes mellitus (T2DM). A total of 60 participants, including 30 males and 30 females aged between 35 and 60 years, were recruited from the Diabetology OPD at Diabetes Speciality Clinic, Sion, Mumbai. Participants were selected using a convenience sampling method. Inclusion criteria comprised individuals who were previously diagnosed with T2DM for a minimum duration of six months, had HbA1c values ranging from 6.5% to 9%, consumed breakfast regularly, and were permanent residents of Mumbai. Pregnant or lactating women and individuals diagnosed with other forms of diabetes were excluded from the study. Ethical clearance for the study was obtained from the Inter System Biomedical Ethics Committee (ISBEC), and written informed consent was collected from all participants after explaining the study objectives. Demographic and lifestyle data were gathered using a pre-designed case record form, which included details such as age, marital status, education, occupation, socioeconomic status (as per the Kuppuswamy scale), medical history, diabetes-related complications, current medications, physical activity, alcohol consumption, smoking habits, and sleep patterns. Anthropometric measurements included body weight, height, and Body Mass Index (BMI), and were recorded using standardized procedures. Body weight was measured to the nearest 0.1 kg using a calibrated digital scale, while height was measured to the nearest 0.1 cm using a stadiometer. BMI was then calculated using the standard formula. Biochemical data, including fasting blood glucose, postprandial blood glucose, and glycated hemoglobin (HbA1c) levels, were collected from participant's medical records maintained at the clinic. Dietary intake was assessed using a 24-hour dietary recall and a semi-quantitative Food Frequency Questionnaire (FFQ).The Breakfast Quality Index (BQI) was calculated using established scoring criteria of the tool. Additionally, the GI and GL of breakfast items were computed using

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the International Tables of Glycemic Index and Load. The Glycemic Index (GI) of each breakfast was calculated using formula [Meal GI= (GI Food A×Available CHO Food A)+(GI Food B×Available CHO Food B) +… / Total Available CHO in the Meal] based on the method outlined by Louie et al. (2011) and the Glycemic Load (GL) was then computed using the formula [GL= Meal GI×Total Available CHO (g) / 100]. Data were analyzed using SPSS Statistics software. Descriptive statistics were used to summarize the demographic, anthropometric, and biochemical characteristics of the participants. Participants were categorized into three groups based on their HbA1c levels to assess the degree of glycaemic control: mildly elevated (6.5-7.0%), moderately elevated (7.1-8.0%), and poorly controlled (8.1-9.0%). Data presented as Mean±SD (standard deviation) or frequency (percentage). To evaluate differences between the groups, one-way Analysis of Variance (ANOVA) was used. Pearson's correlation and one-way ANOVA were applied to examine relationships between BQI, GI, GL, and glycaemic parameters. A $p < 0.05$ was considered to be statistically significant.

3. Results and Discussion

A total of 60 adults (30 males and 30 females) aged between 35 and 60 years with type 2 diabetes mellitus participated in the study. Participants were categorized into three groups based on their HbA1c levels: mildly elevated (6.5-7.0%), moderately elevated (7.1-8.0%), and poorly controlled (8.1-9.0%).

Table no. 1: Demographic Characteristics of the Study Sample According to the HbA1c Levels.

Demographic Factors	Total (60) (N, %)	Mildly elevated HbA1c - 6.5 - 7% (n, %)	Moderately elevated HbA1c - 7.1-8% (n, %)	Poorly controlled HbA1c - 8.1 - 9% (n, %)	Pearson Chi-square test value	p-value
Age (in years)						
35 - 60	60 (100)	19 (31.6)	26 (43.33)	15 (25)	-	-
Gender						
Male	30 (50)	11 (57.9)	12 (46.2)	7 (46.7)	0.694	0.707
Female	30 (50)	8 (42.1)	14 (53.8)	8 (53.3)		
Marital Status						
Unmarried	0 (0)	0 (0)	0 (0)	0 (0)	-	-
Married	60 (100)	19 (100)	26 (100)	15 (100)		
Food habit						
Vegetarian	23 (38.3)	7 (36.8)	11 (42.3)	5 (33.3)	3.395	0.758
Non-vegetarian	35(58.3)	12 (63.2)	13 (50)	10 (66.7)		
Ovo-vegetarian	1 (1.7)	0 (0)	1 (3.8)	0 (0)		
Vegan	0 (0)	0 (0)	0 (0)	0 (0)		
Jain	1 (1.7)	0 (0)	1 (3.8)	0 (0)		
Level of Education of the participants						
No schooling	4 (6.7)	2 (10.5)	2 (7.7)	0 (0)	15.367	0.354
Primary school (1st to 4th standard)	2 (3.3)	0 (0)	0 (0)	2 (13.3)		
Secondary school (5th to 10th standard)	23 (38.3)	5 (26.3)	11 (42.3)	7 (46.7)		
High school (11th to 12th standard)	8 (13.3)	4 (21.1)	2 (7.7)	2 (13.3)		
Diploma	3 (5)	2 (10.5)	1 (3.8)	0 (0)		
Graduate	15 (25)	5 (26.3)	6 (23.1)	4 (26.7)		
Postgraduate	4 (6.7)	1 (5.3)	3 (11.5)	0 (0)		
Doctorate	1 (1.7)	0 (0)	1 (3.8)	0 (0)		
Kuppuswamy SES Scale						
Upper (I)	1 (1.7)	1 (5.3)	0 (0)	0 (0)	7.027	0.534

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Table no. 1 shows the differences in demographic characteristics of study participants. Chi-square test was applied to obtain the association of the variables with glycaemic control of the diabetic patients.

All 60 participants in the study belonged to the age group of 35 to 60 years, which was intentionally selected to focus on adults in the mid-life stage, where the risk for type 2 diabetes is typically higher. Among these, 43.3% (n=26) were found to have moderately elevated HbA1c group, 31.6% (n=19) had mildly elevated group, and 25% (n=15) had poor glycaemic control. While these proportions indicate a greater prevalence of moderate hyperglycemia within this age group, no statistical comparison was conducted for age since the entire sample fell within a single pre-defined age bracket. In this study, the gender ratio was equal, with male-female ratio 1:1. Females had poor glycemic control indicated in poorly controlled HbA1c group (n = 8, 53.3%) than males (n= 7, 46.7%). However, there was no significant difference found between the gender of participants and glycemic control (p = 0.707). All the participants were married accounting for 100%. Among them, the majority had moderately elevated HbA1c levels (n = 26), mildly elevated HbA1c levels had (n= 19), and poorly controlled HbA1c group had (n =15). A large number of the participants were non-vegetarians (n= 35, 58.3%) and vegetarians (n= 23, 38.3%) and a smaller number of participants identifying as ovo-vegetarian (n = 1, 1.7%) and Jain (n= 1, 1.7%). No participants followed a vegan diet. Although variations in food habits were seen across HbA1c groups, no significant difference was found between food preference and glycemic control (p = 0.758).

In terms of education level, participants represented as secondary school (5th to 10th standard) were highest (n = 23, 38.3%), followed by graduate (n =15, 25%), high school (11th to 12th standard) (n = 8, 13.3%), No schooling (n = 4, 6.7%), Diploma (n = 3, 5%), Primary school (1st to 4th standard) (n= 2, 3.3%) and doctorate (n = 1, 1.7%). There was no significant difference between the different groups (p = 0.354). Lastly, the socio-economic status of the participants, using the modified Kuppuswamy SES scale, the majority of the participants (n= 32, 53.3%) belonged to the upper lower class and upper middle class (n = 11, 18.3%). There was no significant difference between the socioeconomic status and glycemic control (p = 0.534). However, a noteworthy number of participants from the upper lower and lower middle class had poor glycemic control. In a study, gender emerged as a noteworthy determinant in glycemic control among individuals with Type 2 Diabetes Mellitus (T2DM). It reported significant gender disparities in glycemic control, with female patients exhibiting poor outcomes compared to their male counterparts (Gebeyaw et al., (2025). This trend could be partly explained by underlying socioeconomic and behavioral variables. Mankar et al. (2024) emphasized that factors such as education, income, occupation, lifestyle practices, and medication adherence significantly influence diabetes management, with gender-specific variations. Similarly, Kassie et al., (2025) highlighted that while females constituted a slightly higher proportion of the study population (52.2%), a greater percentage (44.7%) achieved optimal glycemic control compared to males (29.5%). Interestingly, the lower censoring rate among females (7.5% vs. 18.3% in males).

Table no. 2: Comparison of anthropometric parameters between diabetics with mildly elevated HbA1c, moderately elevated HbA1c and poorly controlled HbA1c.

Variables	Mildly elevated HbA1c - 6.5 - 7% (Mean ± SD)	Moderately elevated HbA1c - 7.1 - 8% (Mean ± SD)	Poorly controlled HbA1c - 8.1 - 9% (Mean ± SD)	Anova Test (F)	p-value
Anthropometric parameters					
Weight	73.71 ± 13.183	72.26 ± 12.778	74.79 ± 12.353	0.197	0.822
Height	164.95 ± 9.384	161.62 ± 11.147	160 ± 10.606	1.001	0.374
BMI (kg/m2)	27.02 ± 4.009	28.00 ± 4.352	29.44 ± 6.06	1.097	0.341

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

The mean heights, weights and BMIs as per the HbA1c levels are shown in Table no.2. Anova test was run to determine the differences in the anthropometry between participants with mild, moderate and poor HbA1c levels.

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The mean weight of participants with poor HbA1c 74.79 ± 12.353 kg was higher than the mean HbA1c levels of mild 73.71 ± 13.183 kg and moderate HbA1c 72.26 ± 12.778 kg groups. Although there was no significant difference between the weight and glycemic control (p = 0.822). A similar trend was observed in the mean BMIs between the groups ie - poor HbA1c group has higher BMI mean (29.44 ± 6.06 kg), followed by moderately elevated HbA1c group (28.00 ± 4.352 kg) and mildly elevated HbA1c group (27.02 ± 4.009 kg), although there was no statistically significant difference found (p=0.341). The relationship between excess body weight and poor glycemic control was evident in the study, (Table 4.2) aligning with existing literature that underscores the impact of obesity on diabetes outcomes. A cross-sectional study by Deng et al. (2025), involving 200 individuals with T2DM, found a significant positive correlation between BMI and HbA1c ($r = 0.45$, $p < 0.001$), with obese participants demonstrating markedly higher HbA1c levels compared to those who were overweight or of normal weight. This pattern reinforces the notion that as BMI increases, glycemic control tends to worsen, highlighting the critical role of weight management in diabetes care. Further supporting this, Boye et al. (2021) analyzed data from a nationally representative U.S. sample and reported that individuals classified in obesity classes I, II, and III were significantly more likely to have HbA1c levels ≥7% and ≥8% than those of normal weight. Similarly, findings by Dias et al. (2025) confirmed a graded relationship between obesity class and glycemic outcomes, where higher obesity classifications were associated with increasingly poor glycemic control. These findings collectively emphasize that targeted strategies to address obesity particularly in its more severe forms are not only essential for metabolic regulation but also for reducing long-term complications in people living with T2DM.

Table no. 3: Comparison of biochemical parameters between mildly elevated HbA1c, moderately elevated HbA1c and poorly controlled HbA1c group among study participants

Variables	Mildly elevated HbA1c - 6.5 - 7% (Mean ± SD)	Moderately elevated HbA1c - 7.1- 8% (Mean ± SD)	Poorly controlled HbA1c - 8.1 - 9% (Mean ± SD)	Anova Test (F)	p-value
Biochemical parameters					
Fasting BS (mg/dL)	116.68 ± 26.981	138.19 ± 50.016	165.00 ± 48.117	5.161	**0.009***
Postprandial BS (mg/dL)	148.96 ± 31.828	208.76 ± 103.607	250.00 ± 75.799	6.91	**0.002***

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table no.3 shows the comparison of fasting blood sugar values and postprandial blood sugar values of the participants with mildly elevated HbA1c group, moderately elevated HbA1c group and poorly controlled HbA1c group. Anova test was used to do the analysis and it showed statistically significant differences in both fasting and postprandial blood sugar values among all the three groups (p=0.009); (p = 0.002). The mean fasting blood sugar (FBS) level showed an increased trend as the HbA1c levels increased indicating poor glycemic control. Mildly elevated group had 116.68 ± 26.981 mg /dL, the moderately elevated group had 138.19 ± 50.016 mg/dL and the poorly controlled HbA1c group had 165.00 ± 48.117 mg/dL among the participants and was statistically significant (p=0.009). Similarly, the mean postprandial blood sugar (PPBS) also a marked rise, from 148.96 ± 31.82 mg/dL in the mildly elevated group to 208.76 ± 103.61 mg/dL in the moderately elevated group, reaching 250.00 ± 75.80 mg/dL in the poorly controlled group, which was also statistically significant (p = 0.002). A significant linear positive correlation between HbA1c levels and both fasting blood sugar (FBS) and postprandial blood sugar (PPBS) values among individuals with Type 2 Diabetes Mellitus. This finding is in line with previous research by Baishya et al. (2023), who reported that patients with higher HbA1c levels consistently exhibited elevated FBS and PPBS values. Their results revealed a stepwise increase in these glycemic parameters across rising HbA1c categories, reinforcing the clinical relevance of HbA1c as a long-term indicator of glucose control. Similarly, Vani et al. (2020) observed a strong correlation between HbA1c and both FBS and PPBS, noting that the association with PPBS was slightly stronger. These findings collectively support the interpretation that worsening glycemic control, as reflected by higher HbA1c, is mirrored by concurrent increases in daily glucose levels. This underscores the utility of HbA1c not only as a diagnostic marker but also as a reliable predictor of both fasting and postprandial glycemic patterns, which are crucial for effective diabetes monitoring and management.

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Table no. 4: Association Between Breakfast Quality Index (BQI) and HbA1c Levels Among Study Participants

Variables	Total (60) (N, %)	Mildly elevated HbA1c - 6.5 - 7% (n, %)	Moderately elevated HbA1c - 7.1 - 8% (n, %)	Poorly controlled HbA1c - 8.1 - 9% (n, %)	Chi-square test value	p-value
Low Quality (BQI: 0-3)	1 (1.7)	0(0)	1 (100)	0 (0)	1.714	0.788
Medium Quality (BQI: 4-6)	25 (41.7)	7 (28)	11 (44)	7 (28)		
High Quality (BQI: 7-10)	34 (56.7)	12 (35.3)	7 (28)	8 (23.5)		
Total (60) (N, %)	60 (100)	19 (13.7)	26 (43.3)	15 (25)		

Frequency Percentage (N, %) *p < 0.05

Table no.4 shows the relationship between Breakfast Quality Index (BQI) scores and glycaemic control among the study participants. A majority of participants with high breakfast quality (BQI 7-10) were observed across all HbA1c categories, particularly among those with mildly elevated HbA1c 35.3% (n= 12), followed by the moderately elevated group 28% (n = 7) and poorly controlled group 23.5% (n = 8). Medium-quality breakfasts (BQI 4-6) were most frequently reported by participants in the moderately elevated HbA1c group 44% (n = 11), with equal proportion 28% (n = 7) in both the mildly elevated and poorly controlled groups. Only one participant, 1.7%, had a low-quality breakfast (BQI 0-3), and this individual belonged to the moderately elevated HbA1c category. There was no significant association between BQI scores and HbA1c levels (p = 0.788). An association in a large sample of low-income European adults, including participants from Italy used a composite breakfast quality index that assessed the presence of key food groups such as whole grains, fruits, and dairy as well as nutrient characteristics like fiber, sugar, and fat content, the researchers found a clear trend: individuals consuming higher-quality breakfasts tended to have healthier overall nutrient profiles and were less likely to exhibit cardiometabolic risk factors such as increased waist circumference, hypertension, and dyslipidemia. Of particular concern was the observation that breakfast quality was often poorer among individuals with higher metabolic risk, suggesting a possible bidirectional relationship between dietary quality and disease progression (de Sousa et al., 2019). Supporting these results, another population-based study explored the impact of breakfast quality using the Breakfast Quality Index (BQI) among Brazilian adults. This index similarly evaluated the inclusion of cereals, fruits, dairy products, and the meal's nutritional adequacy. The study found that individuals with higher BQI scores indicative of more balanced and nutrient-rich breakfasts were significantly less likely to show markers of cardiometabolic dysfunction, including elevated blood pressure, high fasting glucose, and insulin resistance. Moreover, higher breakfast quality was associated with lower HOMA-IR values, suggesting improved insulin sensitivity (Félix et al., 2021).

Table no. 5: Comparison of Breakfast Meal Glycemic Index (GI) and Glycemic Load (GL) across different HbA1c Categories

Variables	Mild elevated HbA1c - 6.5 - 7% (Mean ± SD)	Moderately elevated HbA1c - 7.1 - 8% (Mean ± SD)	Poorly controlled HbA1c - 8.1 - 9% (Mean ± SD)	Anova Test (F)	p-value
GL and GI of Breakfast					
Meal GI	58.87 ± 8.048	58.56 ± 7.111	54.733 ± 9.422	1.382	0.259
Meal GL	27.02 ± 11.999	25.63 ± 11.405	21.366 ± 10.596	1.1	0.34

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

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Table no.5 presents the mean glycaemic index (GI) and mean glycaemic load (GL) of breakfast consumed by participants across different levels of glycaemic control. The mean GI was found to be 58.87 ± 8.048 in the mildly elevated HbA1c group, 58.56 ± 7.111 in the moderately elevated group, and slightly lower at 54.733 ± 9.422 in the poorly controlled group. Though the difference was statistically not significant a downward trend was seen ($p = 0.259$). The mean Glycemic Load (GL) of breakfast meals was highest among those with mildly elevated HbA1c (27.02 ± 11.999), followed by moderately elevated (25.63 ± 11.405), and lowest in the poorly controlled group (21.37 ± 10.596). Again, these differences were not statistically significant ($p = 0.340$). Several studies have underscored the importance of breakfast composition particularly its glycaemic index (GI) and glycaemic load (GL) in influencing metabolic outcomes, especially in individuals with type 2 diabetes. A comprehensive review by Betts et al. (2016) synthesized evidence from both randomized controlled trials and observational studies, highlighting that breakfasts high in rapidly digestible carbohydrates (i.e., high GI/GL) tend to cause greater postprandial glucose spikes and increased insulin demand throughout the day. These effects are even more pronounced in individuals with diabetes, where such meal patterns may contribute to sustained hyperglycemia and elevated HbA1c over time. In contrast, the review emphasized that low-GI and low-GL breakfasts, typically rich in whole grains, fiber, and protein, support more stable glycaemic responses and contribute to improved long-term blood sugar control. The authors concluded that beyond simply eating breakfast regularly, the nutritional quality of the meal, particularly its glycaemic characteristics, plays a critical role in effective diabetes management (Maki et al., 2016). Further supporting these insights, Vlachos et al. (2020) reported that high-GI breakfasts consistently lead to significantly higher postprandial glucose levels in individuals with type 2 diabetes, whereas low-GI meals are linked to improved glycemic profiles and reduced HbA1c values. These findings reinforce dietary guidelines that recommend minimizing the glycaemic impact of breakfast to support better overall glucose regulation. Adding to this evidence base, a 2022 clinical study by Röhling and colleagues explored the immediate metabolic effects of consuming high-GI, low-fiber breakfasts versus low-GI, high-fiber alternatives. The results revealed that participants, particularly those with poorer glycaemic control experienced greater spikes in blood glucose and insulin, along with elevated levels of the hunger hormone ghrelin, after consuming the high-GI, low-fiber meal. These acute metabolic disturbances further underscore the value of lowering GI and increasing dietary fiber at breakfast as a practical strategy for improving postprandial glucose control and potentially achieving better long-term outcomes, including reduced HbA1c (Silva et al., 2015).

Table no. 6: Comparison of Macronutrient intake and Micronutrient intake from breakfast across different HbA1c Categories

Variables	Total (60) (Mean ± SD)	Mild elevated HbA1c - 6.5 - 7% (Mean ± SD)	Moderately elevated HbA1c - 7.1 - 8% (Mean ± SD)	Poorly controlled HbA1c - 8.1 - 9% (Mean ± SD)	Anova test (F)	p-value
Macronutrients						
Energy (kcal)	321.70 ± 118.924	328.63.37 ± 105.347	311.42 ± 127.235	330.733 ± 126.792	0.168	0.846
CHO (g)	44.41 ± 19.588	46.05 ± 18.795	45.015 ± 20.931	41.28 ± 19.120	0.265	0.769
Protein (g)	9.743 ± 6.443	9.22 ± 4.666	9.03 ± 5.472	11.64 ± 9.399	0.868	0.425
Fat (g)	10.91 ± 5.07	11.21 ± 5.03	9.89 ± 4.815	12.28 ± 5.504	1.115	0.335
Micronutrients						
Sodium (mg)	40.60 ± 57.237	43.25 ± 60.377	33.03 ± 34.983	50.37 ± 81.948	0.459	0.634
Potassium (mg)	411.563 ± 262.127	403.46 ± 245.218	387.130 ± 270.544	464.173 ± 278.187	0.416	0.662

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table no.6 shows the mean values and standard deviations of energy, macronutrient, and micronutrient intake from breakfast meals among study participants, categorized by glycaemic control status (mildly elevated, moderately elevated, and poorly controlled HbA1c).

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Macronutrients:

The average energy intake from breakfast was highest among individuals with poorly controlled HbA1c (330.733 ± 126.792 kcal), slightly higher than those in the mildly elevated (328.63.37 ± 105.347 kcal) and moderately elevated groups (311.42 ± 127.235 kcal). However, this variation was not statistically significant (p = 0.846). Carbohydrate intake in the mildly elevated group consuming the highest (46.05 ± 18.795 g), followed by the moderately elevated (45.015 ± 20.931 g) and poorly controlled group (41.28 ± 19.120 g). Despite this downward trend, no statistically significant differences were noted (p = 0.769). Protein consumption was highest among participants with poor glycaemic control (11.64 ± 9.399 g), compared to 9.22 ± 4.666 g in the mildly elevated group and 9.03 ± 5.472 g in the moderately elevated group. Though the differences were not statistically significant (p = 0.425). Similarly, fat intake at breakfast was also highest in the poorly controlled group (12.28 ± 5.504 g) and lowest in the moderately elevated group (9.89 ± 4.815 g), but the difference was not statistically significant (p = 0.335).

Micronutrients:

Breakfast sodium intake was slightly higher among individuals with poor glycaemic control (50.37 ± 81.948 mg) compared to those with moderately (33.03 ± 34.983 mg) and mildly elevated HbA1c (43.25 ± 60.377 mg). Despite the variation, no significant difference was observed (p = 0.634). Potassium intake ranged from 387.130 ± 270.544 mg in the moderately elevated group to 403.46 ± 245.218 mg in the mildly elevated group. Those in the poorly controlled group had a mean intake of 464.173 ± 278.187 mg. However, the differences were not statistically significant (p = 0.662), suggesting uniformity in potassium consumption at breakfast across groups. The highest fiber intake was recorded in the mildly elevated group (6.07 ± 4.306 g), while the poorly controlled group had the lowest intake (5.88 ± 4.24 g). However, the difference was not statistically significant (p = 0.987). Average calcium intake showed a decreasing trend from mildly elevated (124.92 ± 75.7 mg), followed by moderately elevated HbA1c (101.26 ± 74.63) and poorly controlled HbA1c group (94.33 ± 73.0 mg). Calcium intake was decreasing among individuals with poorer glycemic control, although the difference was not statistically significant (p = 0.436). Saturated fat intake at breakfast was high among those with poorly controlled diabetes (3971.60 ± 2234.519 mg) compared to in the mildly elevated group (3584.20 ± 2191.303mg) and moderately elevated group (3498.74 ± 2426.945 mg). Although the difference was not statistically significant (p=0.812). Free sugar intake appeared to be highest among individuals in the moderately elevated group (3.06 ± 3.08 g), followed by mildly elevated (1.85 ± 2.81 g) and poorly controlled participants (1.25 ± 2.92 g). However, the difference was not statistically significant (p = 0.146). None of the differences in nutrient intake from breakfast reached statistical significance. However, several trends emerged: individuals with poor glycaemic control consumed slightly more total energy, fat, saturated fat, and protein, while those with mildly elevated HbA1c showed higher fiber and calcium intakes. Although the study did not reveal statistically significant differences in breakfast-related energy, macronutrient, or micronutrient intake across the glycaemic control categories. However, several meaningful dietary trends emerged that are both clinically relevant and consistent with existing literature on type 2 diabetes management. Participants with poor glycaemic control tended to consume higher amounts of total energy, fat, saturated fat, and protein at breakfast compared to those with mildly or moderately elevated HbA1c. Although these differences did not reach statistical significance, the observed trend suggests a potential association between higher energy-dense breakfasts and suboptimal glycaemic regulation. These findings align with the study, which reported that diets high in calories and saturated fats contribute to insulin resistance and elevated HbA1c levels. The study supports the notion that managing energy and saturated fat intake is crucial in minimizing metabolic dysfunction among individuals with type 2 diabetes (Thipsawat et al., 2023). Conversely, participants with mildly elevated HbA1c appeared to consume more dietary fiber and calcium at breakfast. This pattern is supported by the findings of a systematic review demonstrating that high-fiber, low-glycaemic index diets are effective in improving postprandial glucose control and lowering HbA1c, even in the absence of weight loss. Fiber's known role in modulating glucose absorption and enhancing satiety may help explain why individuals with better glycaemic control in this study had slightly higher breakfast fiber intake (Gerontiti et al., 2024). Micronutrient intake including sodium, potassium, and calcium did not vary significantly between groups, though descriptive patterns suggested slightly higher sodium and potassium intakes among individuals with poor glycaemic control. However, as emphasized by Salvia et al. (2023), nutrient balance and overall dietary quality are likely more important than isolated micronutrient levels when it comes to supporting glycaemic outcomes. Their work

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advocates for a comprehensive dietary approach that considers not just what nutrients are consumed, but how they are combined, timed, and distributed across meals.

Interestingly, saturated fat intake at breakfast was highest among the poorly controlled group, while free sugar intake showed a different pattern, peaking among participants with moderately elevated HbA1c. While these findings did not reach statistical significance, they reflect the metabolic complexity of dietary patterns and their potential role in influencing insulin sensitivity and postprandial glucose excursions (p=0.146) (Gerontiti et al., 2024). With regard to free sugar intake, this study found a non-significant trend toward higher free sugar consumption at breakfast in the moderately elevated HbA1c group. A study had similar findings which explained that excessive free sugar intake is associated with an increased risk of type 2 diabetes, its negative effects are often mediated through excess calorie intake and subsequent weight gain rather than the sugar itself. Benton emphasizes that reducing free sugar intake remains an important component for optimizing blood sugar control, but also for promoting cardiovascular health (Benton et al., 2023). In summary, although the statistical analysis did not confirm significant associations, the emerging trends are consistent with current dietary recommendations for type 2 diabetes. These observations suggest that higher energy and saturated fat intake may be associated with poorer glycaemic control, while increased fiber and calcium intake may contribute to more favorable outcomes.

Table no. 7: Correlation Between Breakfast Quality and Biochemical Parameters among the study participants

Breakfast Quality Index		
	Pearson Correlation (r)	**p-value**
Fasting blood glucose levels	-0.236	0.071
Post-prandial blood glucose levels	-0.228	0.082
HbA1c levels	-0.23	0.861

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table no.7 illustrates the correlation between the Breakfast Quality Index (BQI) and key glycemic markers, namely fasting blood glucose, post-prandial blood glucose, and HbA1c levels. Although the correlations were not statistically significant, a negative correlation was observed between breakfast quality and all three glycemic indicators- Fasting blood glucose ($r = -0.236$, $p= 0.071$), Post-prandial blood glucose ($r = -0.228$, $p = 0.082$) and HbA1c levels ($r = -0.230$, $p = 0.861$).

These results suggest that participants with higher BQI scores (i.e., healthier breakfasts) tended to have lower blood glucose levels and improved glycemic control, although the associations did not reach significance. Studies have consistently shown that the frequency and nutritional composition of breakfast are associated with improved blood sugar control and reduced risk of type 2 diabetes.A study conducted by Pereira et al. (2011), observed in their pilot studies that breakfasts rich in fiber and essential nutrients were linked to more favorable postprandial glucose and insulin responses, suggesting that breakfast quality can meaningfully influence metabolic outcomes.

Similarly, in a systematic review, which examined both randomized controlled trials and cohort studies to assess the relationship between meal timing, frequency, and glycemic control in individuals with type 2 diabetes. Their findings revealed that skipping breakfast was consistently associated with poorer glycemic outcomes, including elevated HbA1c and greater glucose variability. In contrast, individuals who regularly consumed balanced, nutrient-dense breakfasts exhibited better glycemic profiles. The review also emphasized that meal timing and frequency influence circadian rhythms, insulin sensitivity, and overall metabolic health, underscoring the importance of structured dietary patterns in diabetes management (Gómez-Ruiz et al., 2024). In support of this, Santana et al. (2025) summarized updated dietary guidelines and recent reviews which highlight that higher overall dietary quality especially when it includes fiber, whole grains, and micronutrient-rich foods at breakfast is associated with lower fasting glucose and HbA1c over time in people with diabetes. These findings suggest that

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breakfast is not only essential as a daily meal but also plays a strategic role in long-term glycemic control when designed with quality in mind. Furthermore, the Breakfast Quality Index (BQI) developed and validated by Pereira and colleagues provides a structured framework for evaluating breakfast quality based on specific food groups and nutrient profiles. The index considers elements such as fruit, whole grain, and dairy inclusion, along with macronutrient and micronutrient balance. Their large-scale study in a Brazilian population found that individuals with higher BQI scores had significantly better overall nutrient intakes, including higher fiber, vitamins, and minerals, and lower saturated fat and added sugar intake. These individuals also showed favorable cardiometabolic markers, such as lower fasting glucose, blood pressure, and a reduced risk of metabolic syndrome, thereby validating the practical use of BQI in assessing breakfast's impact on metabolic health (Félix et al., 2021). Together, these findings reinforce the causal link between breakfast frequency, quality, and glycemic outcomes, and suggest that public health strategies should not only promote breakfast consumption but also prioritize improving the nutritional quality of morning meals. For individuals with or at risk for type 2 diabetes, adopting a breakfast pattern rich in fiber, low-GI carbohydrates, and essential micronutrients may provide meaningful benefits in managing glycemia and reducing long-term metabolic risk.

Table no. 8: Correlation Between Breakfast Quality and Glycemic Index/ Load of breakfast among the study participants

	Breakfast Quality Index	
	Pearson Correlation (r)	**p-value**
Breakfast Glycemic Index	0.318	**0.013***
Breakfast Glycemic Load	0.32	**0.013***

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table no.8 assesses the relationship between BQI and the glycemic index (GI) and glycemic load (GL) of breakfast meals.

A significant positive correlation was found between BQI and Breakfast GI ($r = 0.318$, $p = 0.013$). Similarly, a positive correlation was also observed with BQI and Breakfast GL ($r = 0.320$, $p = 0.013$). These findings seem to be contradictory, it is generally assumed that higher-quality breakfasts would be associated with lower glycemic impact. However, this could be due to the inclusion of whole fruits, dairy, or cereals that, while nutritious, still contribute to the glycemic index or load. It suggests that a higher BQI does not necessarily translate into lower glycemic responses. An unexpected yet noteworthy finding from the present study is the significant positive correlation between the Breakfast Quality Index (BQI) and both the glycemic index (GI) and glycemic load (GL) of breakfast meals. Such an observation contradicts the common perception that higher-quality breakfasts are always associated with lower glycemic impact. Instead, it suggests that among adults with type 2 diabetes, nutrient-dense breakfasts may still possess moderate to high GI and GL values, likely due to the inclusion of foods such as whole fruits, dairy products, and certain cereals. These foods contribute essential nutrients but may also elevate the glycemic response. A study conducted by Peres et al. (2023), highlights that nutrient-dense foods commonly included in high-quality breakfasts such as fruits, whole grains, and dairy products tend to have moderate glycemic index (GI) and glycemic load (GL) values. Despite their glycemic properties, these foods are considered essential due to their rich content of fiber, phytochemicals, and vital micronutrients. Similarly, a clinical study by Silva et al. (2015) demonstrated that high-GI, low-fiber breakfasts led to less favorable glucose and insulin responses compared to low-GI, high-fiber alternatives, even when both types of meals had acceptable overall quality. These findings illustrate that glycemic characteristics and nutritional quality do not always align in a linear manner. The complexity of mixed meals further complicates glycemic predictions. The Linus Pauling Institute (2025) notes that GI and GL values of a mixed meal are influenced not only by carbohydrate type but also by fiber, fat, and protein content, as well as the food matrix and preparation methods. This means that a meal can rank highly on a quality index like BQI while still having a relatively high glycemic impact, depending on its composition. Thus, GI and GL values derived from isolated food items may not accurately reflect postprandial

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responses in the context of mixed, nutrient-rich meals. Moreover, large-scale epidemiological studies continue to associate higher dietary GI and GL with increased risk of type 2 diabetes and suboptimal glycemic control (Greenwood et al., 2013; Livesey et al., 2019). However, these studies also emphasize the importance of evaluating overall dietary patterns, including micronutrient density, fiber intake, and food diversity, when assessing the health implications of carbohydrate consumption. In summary, the positive association between BQI and breakfast GI/GL in this study highlights a key nuance in dietary assessment: high nutritional quality does not always equate to low glycemic impact.

Table no. 9: Correlation Between Breakfast Quality and Anthropometric Parameters among the study participants

	Breakfast Quality Index	
	Pearson Correlation (r)	**p-value**
Weight	-0.225	0.084
Height	0.039	0.766
BMI	-0.354	**0.005****

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table no. 9 shows the correlation Between Breakfast Quality Index and Anthropometric Parameters

This table explores how the Breakfast quality index relates to body measurements, such as weight, height, and BMI. BMI showed a significant negative correlation with breakfast quality index ($r = -0.354$, $p = 0.005$), indicating that better breakfast quality was associated with lower BMI. This suggests a possible protective role of breakfast composition in weight management or obesity prevention. Weight has negative correlation with breakfast quality index ($r = -0.225$), though not significantly ($p = 0.084$). Height had positive correlation with breakfast quality index, but it was not statistically significant ($r = 0.039$, $p = 0.766$).

A significant inverse relationship between the Breakfast Quality Index (BQI) and Body Mass Index (BMI), suggesting that participants who consumed higher-quality breakfasts tended to have lower BMI. In a recent cross-sectional study, Martinez et al. (2024) showed the relationship between breakfast quality and anthropometric outcomes in a large adult population using the Breakfast Quality Index (BQI). The findings revealed that individuals with higher BQI scores indicative of more balanced and nutrient-rich breakfast patterns had significantly lower body mass index (BMI) compared to those with lower-quality breakfasts. It highlighted that consuming a breakfast rich in fiber, whole grains, fruits, and dairy was independently associated with healthier weight status, even after adjusting for confounding variables such as age, sex, and levels of physical activity. Further support comes from a 2024 longitudinal analysis by Pérez-Vega et al., which examined older adults with metabolic syndrome, a group at elevated risk for type 2 diabetes. Their findings indicated that higher breakfast quality was associated with lower BMI, smaller waist circumference, and favorable lipid profiles. Conversely, individuals who consumed lower-quality breakfasts experienced greater adiposity and poorer cardiometabolic health (Pérez-Vega et al., 2024a; 2024b). These results reinforce the idea that breakfast composition plays a pivotal role not only in energy balance but also in reducing long-term metabolic risk. Similarly, there was a negative correlation between BQI and body weight ($r = -0.225$, $p = 0.084$) did not reach statistical significance but did mirror the BMI trend, suggesting that breakfast quality may impact body composition more meaningfully when adjusted for height. As expected, no significant association was found between BQI and height ($r = 0.039$, $p = 0.766$), consistent with the understanding that adult height is primarily influenced by genetics and early-life nutrition, rather than current dietary behaviors. Moreover, physiological mechanisms provide further insight into these associations. Research by Clayton et al. (2016) underscores the hormonal advantages of breakfast consumption. Eating breakfast has been shown to increase satiety hormones such as GLP-1 and PYY while suppressing ghrelin, the hunger hormone. In contrast, skipping breakfast leads to greater post-meal glucose and insulin spikes, a phenomenon known as the "second meal effect" which can disrupt glycaemic control and appetite regulation throughout the day. Complementary findings by Pérez-Vega et al. (2024c) revealed that breakfast

skipping was associated with higher BMI and greater metabolic risk, whereas regular breakfast intake was linked to better quality of life and reduced obesity prevalence. These insights suggest that targeted interventions promoting regular, high-quality breakfasts may be a practical and effective strategy to support metabolic health in adults with or at risk for type 2 diabetes.

4. Conclusion

This study underscores the multifaceted role of breakfast in glycaemic management among adults with type 2 diabetes mellitus (T2DM). The findings highlight that beyond simply consuming breakfast, the nutritional composition, timing, and glycemic characteristics of the breakfast are critical factors influencing metabolic outcomes such as fasting glucose, postprandial glucose, and HbA1c levels. Although the observed negative associations between the Breakfast Quality Index (BQI) and glycaemic parameters were not statistically significant, the trends suggest that higher breakfast quality may be linked with better glycaemic control. Participants who regularly consumed nutritionally balanced breakfasts, particularly those rich in fiber, protein, calcium, and essential micronutrients showed more favorable BMI and glucose profiles. Interestingly, the study also found a significant positive correlation between BQI and both glycemic index and glycemic load, indicating that a breakfast deemed high in quality may still exert a substantial glycaemic impact, depending on the types and characteristics of carbohydrates consumed. This nuanced relationship emphasizes the need to consider not only the overall nutrient quality but also the glycaemic properties of foods, especially for individuals with T2DM, who are sensitive to postprandial glucose excursions. Furthermore, patterns of increased energy intake later in the day and more frequent breakfast skipping were more common among individuals with poorer glycaemic control. These behavioral trends point to the potential influence of meal timing and circadian alignment on metabolic health. In conclusion, the results of this study contribute to a growing body of evidence suggesting that breakfast quality, along with its glycemic index and load, are relevant and modifiable dietary components in the management of T2DM. Interventions that focus on improving the nutritional quality and timing of breakfast may offer a practical and effective strategy to support glycaemic control in this population.

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