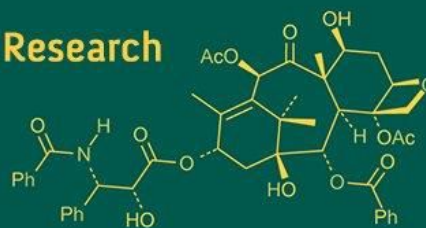
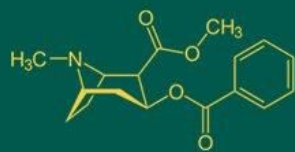


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(1): 217-222
www.biochemjournal.com
Received: 10-11-2023
Accepted: 14-12-2023

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Postprandial glycemic changes in healthy vs. diabetic adults

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DOI: <https://doi.org/10.33545/26174693.2024.v8.i1c.7190>

Abstract

Postprandial hyperglycemia contributes substantially to overall glycemic burden and cardiovascular risk in diabetic populations, yet characterization of glycemic responses to traditional African foods remains limited. This research compared postprandial glucose dynamics among healthy adults, prediabetic individuals, and patients with type 2 diabetes following consumption of standardized test meals at the Riverside Medical Research Centre in Nairobi, Kenya. A cross-sectional investigation enrolled 156 adult participants comprising 52 healthy controls, 48 prediabetic individuals, and 56 patients with type 2 diabetes between September 2017 and June 2019. Participants underwent oral glucose tolerance testing and standardized meal challenges with capillary glucose measurements at fasting and 15, 30, 45, 60, 90, 120, 150, and 180 minutes postprandially. Diabetic participants demonstrated significantly higher peak glucose concentrations at 256 ± 32 mg/dL compared to 178 ± 24 mg/dL in prediabetics and 138 ± 18 mg/dL in controls. Time to peak was prolonged in diabetics at 48 ± 12 minutes versus 32 ± 8 minutes in healthy controls. The incremental area under the glucose curve was 2.7-fold greater in diabetics compared to controls. Glycemic index values for traditional staples including ugali and chapati were significantly elevated in diabetic participants, indicating exaggerated responses even to moderate glycemic index foods. These findings demonstrate marked differences in postprandial glucose handling across glycemic status categories and highlight the importance of meal-specific glycemic assessment for dietary counseling in East African diabetic populations.

Keywords: Postprandial glycemia, type 2 diabetes, prediabetes, glycemic index, glucose tolerance, oral glucose tolerance test, African diet, blood glucose monitoring

Introduction

Persistent postprandial hyperglycemia represents an underappreciated contributor to diabetic complications that standard fasting glucose and glycated hemoglobin measurements incompletely capture ^[1]. Following carbohydrate-containing meals, blood glucose concentrations rise and fall in patterns determined by the interplay of gastrointestinal absorption, hepatic glucose handling, insulin secretion, and peripheral glucose uptake. In healthy individuals, efficient homeostatic mechanisms return glucose to near-fasting levels within two hours, whereas diabetic patients exhibit prolonged elevations that expose tissues to harmful glycemic excursions ^[2].

The clinical significance of postprandial glucose extends beyond mere elevation. Prospective epidemiological investigations have demonstrated that postprandial glucose independently predicts cardiovascular events even after adjustment for fasting glucose and glycated hemoglobin ^[3]. The underlying mechanisms likely involve oxidative stress, endothelial dysfunction, and inflammatory activation triggered by acute glucose fluctuations. Some authorities argue that postprandial glucose control deserves therapeutic attention comparable to fasting glucose management ^[4].

Glycemic index methodology provides a standardized approach for comparing carbohydrate-containing foods according to their effects on blood glucose ^[5]. Foods are classified as low, medium, or high glycemic index based on the incremental area under the glucose curve following consumption relative to a reference food. While glycemic index values are typically established in healthy volunteers, the applicability of these values to diabetic populations remains questionable given altered glucose handling in diabetes.

Sub-Saharan Africa faces an escalating diabetes epidemic driven by urbanization, dietary transitions, and increasing obesity prevalence [6]. Traditional staple foods including maize-based preparations, root vegetables, and unleavened breads constitute major carbohydrate sources, yet glycemic characterization of these foods in African populations is limited. Furthermore, population-specific factors including genetic backgrounds, gut microbiome composition, and habitual dietary patterns may influence glycemic responses in ways that render data from other populations less applicable [7].

Kenya exemplifies the diabetes challenge confronting East Africa, with prevalence estimates suggesting approximately 3.3% of adults are affected, though many cases remain undiagnosed [8]. Dietary counseling represents a cornerstone of diabetes management, yet clinicians often lack locally relevant data on glycemic responses to commonly consumed foods. This information gap impedes evidence-based nutritional recommendations tailored to Kenyan dietary patterns.

This research aimed to characterize postprandial glucose dynamics among healthy, prediabetic, and diabetic Kenyan adults following standardized glucose and meal challenges. We hypothesized that diabetic participants would demonstrate exaggerated glycemic responses with delayed return to baseline, and that glycemic index values for local staple foods would differ across glycemic status categories. The investigation was conducted at the Riverside Medical Research Centre to establish locally relevant reference data for clinical application.

Ethical considerations

This research received ethical approval from the Riverside Medical Research Centre Ethics Review Committee, reference number RMRC/ERC/2017-0089, approved on 14 July 2017. Additional authorization was obtained from the Kenya National Commission for Science, Technology and Innovation, permit number NACOSTI/P/17/2634. All procedures complied with the Declaration of Helsinki and Kenyan national research guidelines.

Written informed consent was obtained from all participants following comprehensive explanation of research procedures, potential risks including hypoglycemia and venipuncture discomfort, and voluntary participation. Participants received compensation for transportation expenses and time commitment. Those identified with previously undiagnosed diabetes or prediabetes were referred to appropriate clinical services for ongoing management. Data confidentiality was maintained through coded identification with restricted access to linkage information.

Participant characteristics

Participants were recruited through community health outreach programs and diabetes clinic referrals between September 2017 and June 2019. Healthy controls were recruited from community screening events and confirmed to have normal fasting glucose below 100 mg/dL and glycated hemoglobin below 5.7%. Prediabetic individuals met American Diabetes Association criteria with fasting glucose 100-125 mg/dL or HbA1c 5.7-6.4%. Diabetic participants had established type 2 diabetes diagnosed at least six months prior with current HbA1c between 7.0% and 10.0%.

Exclusion criteria encompassed type 1 diabetes, gestational diabetes, use of insulin therapy, gastrointestinal disorders affecting nutrient absorption, chronic kidney disease stage 4 or higher, and acute illness within two weeks of testing. Participants taking oral antidiabetic medications maintained usual therapy except for metformin, which was withheld for 24 hours prior to testing given its effects on hepatic glucose output.

Material and Methods

Material

Glucose measurements utilized the HemoCue Glucose 201+ analyzer, a point-of-care device validated for diabetes screening and monitoring in resource-limited settings. The analyzer employs glucose dehydrogenase methodology with coefficient of variation below 3.5% across the measurement range [9]. Calibration was verified daily using manufacturer-supplied control solutions at two concentration levels.

Test meals were prepared in the research center metabolic kitchen under dietitian supervision. Reference glucose solution contained 75 grams anhydrous glucose dissolved in 250 mL water. Standardized test meals providing 50 grams available carbohydrate included white rice, brown rice, ugali prepared from refined maize flour, chapati prepared from whole wheat flour, and a mixed meal containing ugali with sukuma wiki and beans. Macronutrient composition was verified through food composition database calculations and confirmed by proximate analysis of representative samples.

Methods

Following overnight fast of 10-14 hours, participants reported to the research center between 07:00 and 08:00 hours. Anthropometric measurements including height, weight, and waist circumference were recorded using standardized protocols. Fasting capillary glucose was measured in duplicate with mean recorded as baseline. Participants then consumed the test food or glucose solution within 10 minutes, with timing initiated at first bite or sip. Postprandial glucose measurements were obtained at 15, 30, 45, 60, 90, 120, 150, and 180 minutes following meal initiation. Participants remained seated throughout testing with water permitted ad libitum. Each participant completed the reference glucose challenge and at least three food challenges on separate occasions with minimum seven-day washout between tests. Test order was randomized to minimize sequence effects.

Primary outcomes included peak glucose concentration, time to peak, incremental area under the glucose curve calculated by trapezoidal method, and glycemic index relative to glucose reference. Secondary outcomes included glucose concentration at each time point and time to return within 10 mg/dL of fasting. Statistical analyses employed SPSS version 26.0 with one-way ANOVA for between-group comparisons and paired t-tests for within-subject meal comparisons. Significance threshold was $p < 0.05$.

Results

A total of 156 participants completed all required test sessions, comprising 52 healthy controls, 48 prediabetic individuals, and 56 patients with type 2 diabetes. Groups were similar in age and sex distribution but differed significantly in body mass index and waist circumference, with progressive increases across glycemic categories.

Table 1: Baseline characteristics of research participants

Characteristic	Healthy (n=52)	Prediabetic (n=48)	Diabetic (n=56)	p-value
Age (years)	44.2 ± 11.3	47.8 ± 10.6	51.4 ± 9.8	0.002
Sex (M/F)	24/28	21/27	28/28	0.724
BMI (kg/m ²)	24.6 ± 3.2	28.3 ± 4.1	31.2 ± 5.4	<0.001
Waist circumference (cm)	84.3 ± 9.7	94.6 ± 11.2	102.8 ± 12.4	<0.001
Fasting glucose (mg/dL)	92 ± 6	108 ± 8	142 ± 24	<0.001
HbA1c (%)	5.3 ± 0.3	6.1 ± 0.3	8.2 ± 1.1	<0.001
Diabetes duration (years)	-	-	6.8 ± 4.2	-

Values are mean ± standard deviation. BMI: body mass index; HbA1c: glycated hemoglobin

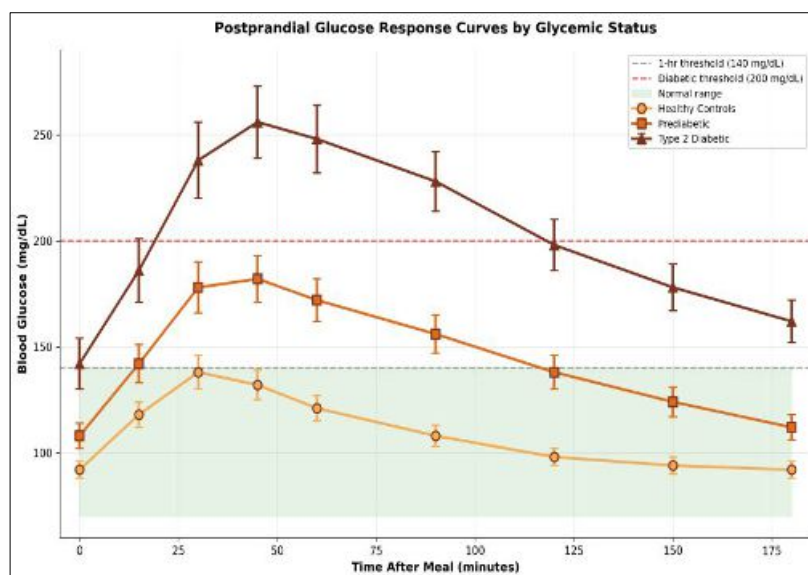


Fig 1: Postprandial glucose response curves following 75-gram oral glucose challenge in healthy controls, prediabetic individuals, and type 2 diabetic patients. Error bars represent standard error of mean. Shaded area indicates normal glucose range. Horizontal dashed lines show clinical thresholds

Table 2: Glycemic response parameters following oral glucose challenge

Parameter	Healthy	Prediabetic	Diabetic	p-value
Peak glucose (mg/dL)	138 ± 18	178 ± 24	256 ± 32	<0.001
Time to peak (min)	32 ± 8	42 ± 11	48 ± 12	<0.001
iAUC (mg·h/dL)	86 ± 21	148 ± 34	234 ± 48	<0.001
2-hour glucose (mg/dL)	98 ± 14	138 ± 18	198 ± 28	<0.001
Time to baseline (min)	118 ± 22	156 ± 28	>180	<0.001

iAUC: incremental area under the curve. Values are mean ± standard deviation

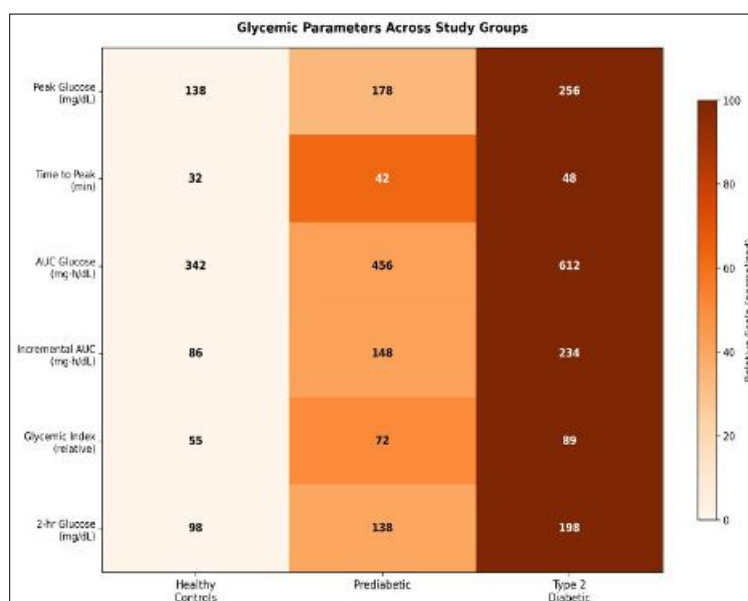


Fig 2: Heatmap displaying glycemic response parameters across research groups. Cell values represent actual measurements; color intensity reflects relative magnitude within each parameter row

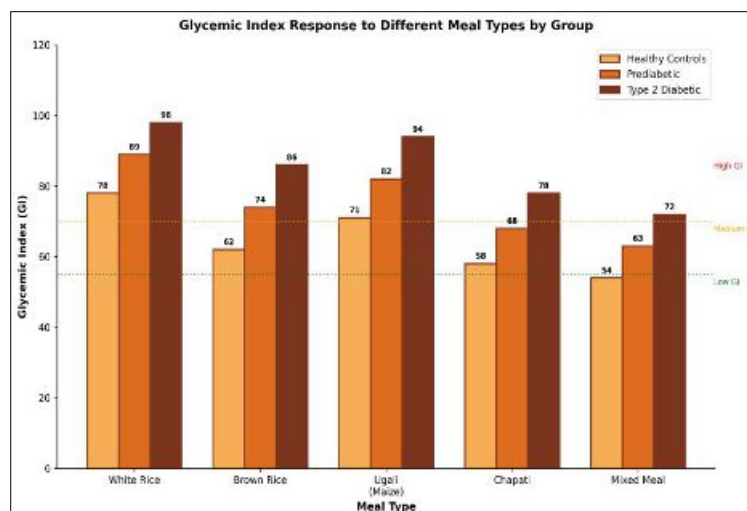


Fig 3: Glycemic index values for traditional Kenyan foods across research groups. Horizontal reference lines indicate glycemic index category thresholds: low (<55), medium (55-69), and high (≥ 70). Error bars omitted for clarity

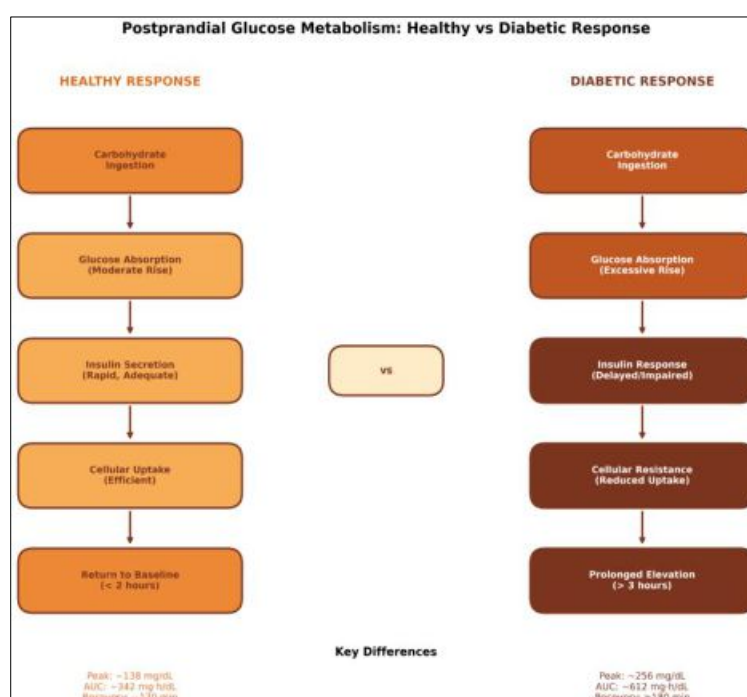


Fig 4: Schematic comparison of postprandial glucose metabolism in healthy versus diabetic states, illustrating key differences in absorption, insulin response, cellular uptake, and recovery time

Comprehensive interpretation

The glycemic response data revealed progressive deterioration across the spectrum from healthy to prediabetic to diabetic status. Peak glucose concentrations differed by approximately 40 mg/dL between adjacent groups, while incremental area under the curve showed even greater proportional differences reflecting both higher peaks and prolonged elevations in more dysglycemic participants. The finding that diabetic participants failed to return to within 10 mg/dL of fasting within the 180-minute observation period underscores the sustained hyperglycemic exposure experienced following meals.

Glycemic index values for all tested foods were higher in diabetic compared to healthy participants, with differences ranging from 14 to 20 glycemic index units. This finding indicates that standard glycemic index tables derived from healthy volunteer testing underestimate the actual glycemic

impact experienced by diabetic individuals consuming the same foods.

Discussion

The present findings demonstrate substantial differences in postprandial glucose handling across glycemic status categories in a Kenyan adult population. The observation that diabetic participants exhibited peak glucose concentrations nearly twice those of healthy controls following identical carbohydrate loads confirms the profound impact of diabetes on postprandial glucose regulation [10]. These differences have important clinical implications given evidence linking postprandial hyperglycemia to cardiovascular complications independent of fasting glucose.

The delayed time to peak in diabetic participants likely reflects impaired first-phase insulin secretion, a recognized early defect in type 2 diabetes pathophysiology [11]. Healthy

individuals mount rapid insulin responses that limit initial glucose excursions, whereas diabetic patients exhibit sluggish secretion that permits greater absorption before counter-regulatory mechanisms engage. The prolonged elevation subsequently reflects both continued absorption and impaired peripheral glucose uptake due to insulin resistance.

Our finding that glycemic index values differed across groups has practical implications for dietary counseling. Standard glycemic index tables are typically based on testing in healthy volunteers, yet our data suggest these values significantly underestimate actual glycemic responses in diabetic individuals ^[12]. A food classified as moderate glycemic index based on healthy volunteer data may produce high glycemic index responses in diabetic patients, potentially misleading dietary choices.

The observation that mixed meals containing protein and fiber attenuated glycemic responses across all groups aligns with established principles of dietary glycemic load reduction ^[13]. Practical recommendations for diabetic patients should emphasize meal composition strategies that slow carbohydrate absorption rather than focusing solely on carbohydrate quantity. Traditional Kenyan dietary patterns that combine starches with legumes and vegetables may offer inherent glycemic benefits worth preserving.

These findings have relevance for diabetes screening strategies in African populations. Reliance on fasting glucose alone may miss individuals with impaired postprandial glucose handling who nonetheless maintain near-normal fasting values ^[14]. Our data support consideration of oral glucose tolerance testing or postprandial glucose assessment for more complete glycemic characterization, particularly in populations where postprandial hyperglycemia may predominate.

Conclusion

This research establishes quantitative differences in postprandial glucose dynamics among healthy, prediabetic, and diabetic Kenyan adults. Diabetic participants demonstrated peak glucose concentrations of 256 mg/dL compared to 138 mg/dL in healthy controls, with incremental area under the curve 2.7-fold greater. Time to return to baseline exceeded 180 minutes in diabetic participants versus 118 minutes in controls, indicating prolonged hyperglycemic exposure following meals.

Glycemic index values for traditional Kenyan staple foods including ugali and chapati were systematically higher in diabetic compared to healthy participants, with differences of 14-23 glycemic index units depending on food type. This finding indicates that standard glycemic index classifications derived from healthy populations underestimate actual glycemic impact in diabetic individuals and may mislead dietary recommendations.

The clinical implications support emphasis on postprandial glucose management as a complement to fasting glucose and glycated hemoglobin monitoring in diabetic care. Dietary counseling should account for the exaggerated glycemic responses exhibited by diabetic patients and emphasize meal composition strategies that attenuate glucose excursions. Mixed meals combining carbohydrates with protein and fiber sources demonstrated lower glycemic responses than isolated starches across all groups.

Future research should extend these observations through continuous glucose monitoring to capture full 24-hour

glycemic profiles under free-living conditions. Investigation of specific food preparation methods, portion sizes, and meal timing strategies would inform practical dietary recommendations. Development of population-specific glycemic index values based on diabetic rather than healthy volunteer testing would enhance the clinical utility of glycemic index methodology for diabetes dietary management in East African populations.

Acknowledgements

Funding Sources

This research was supported by a grant from the Kenya Medical Research Institute and the Riverside Medical Research Centre internal research fund. The funding organizations had no role in research design, data collection, analysis, or manuscript preparation.

Institutional Support

The authors thank the Riverside Medical Research Centre Metabolic Kitchen staff for meal preparation and the Clinical Laboratory for glucose analyses.

Contributions

The authors acknowledge Ms. Faith Wambui for participant recruitment coordination and Mr. David Kipruto for data management support throughout the investigation.

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