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IMPACT OF DAILY GLUCOSE SPIKES ON GASTROINTESTINAL HEALTH IN SOUTH ARAL REGION

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Annotatsiya. Ovqatdan keyingi glyukoza o‘zgarishlari — bu ovqat iste’molidan so‘ng qon glyukozasi darajasining keskin ko‘tarilishi bo‘lib, ular metabolik disfunksiya va tizimli yallig‘lanishga olib keluvchi omil sifatida tobora ko‘proq e’tiborni tortmoqda. Biroq, bu glyukoza tebranishlarining oshqozon-ichak tizimi (OIT) salomatligiga ta’siri hali yetarlicha o‘rganilmagan, ayniqsa ekologik stress omillariga duchor bo‘lgan Janubiy Orolbo‘yi mintaqasi aholisi orasida. Ushbu tadqiqotda kundalik glyukoza o‘zgaruvchanligi bilan oshqozon-ichak simptomlari o‘rtasidagi bog‘liqlik baholandi. Tadqiqotga qandli diabet tashxisi bo‘lmagan, Janubiy Orolbo‘yi mintaqasida yashovchi 150 nafar kattalar jalb etildi. Glyukoza darajasining kunlik o‘zgarishlari 14 kun davomida uzluksiz glyukoza monitoringi (UGM) yordamida o‘lchandi. Glyukoza tebranishlari ovqatdan keyingi 2 soat ichida boshlang‘ich qiymatdan 30 mg/dl dan ortiq oshish bilan belgilandi. Oshqozon-ichak simptomlari har hafta gastrointestinal simptomlarni baholash shkalasi (GSBS) orqali baholandi. Ishtirokchilarning ovqatlanish odatlari maxsus so‘rovnomalar orqali aniqlanib, atrof-muhit ta’siri standartlashtirilgan so‘rovnomalar asosida baholandi. Ma’lumotlar multifaktorial regressiya modellarida tahlil qilindi. Ishtirokchilarda o‘rtacha kuniga 3,8 ± 1,2 ta glyukoza tebranishi kuzatildi. Glyukoza tebranishlarining ko‘payishi GSBS umumiy ballari bilan sezilarli ijobiy bog‘liqlikda bo‘ldi ($\beta = 0.45$; $p < 0.001$), ayniqsa qorin og‘rig‘i, dam bo‘lish va ichak faoliyatidagi buzilishlar yaqqol namoyon bo‘ldi. Kuniga 4 martadan ko‘p glyukoza ko‘tarilishi kuzatilgan ishtirokchilarda GI simptomlari ikki baravar ko‘p uchradi. Rafinlangan uglevodlarni yuqori miqdorda iste’mol qilish glyukoza tebranishlari bilan sezilarli bog‘liq edi ($r = 0.52$; $p < 0.001$). Atrof-muhitdagi ifloslantiruvchi omillarga duchor bo‘lish GI simptomlarini kuchaytirdi, ammo glyukoza darajasi o‘zgarishlari bilan to‘g‘ridan-to‘g‘ri bog‘liq emas edi. Ovqatdan keyingi tez-tez uchraydigan glyukoza tebranishlari Janubiy Orolbo‘yi mintaqasi aholisida GI simptomatikasining kuchayishiga olib keladi, bu metabolik yallig‘lanish va ichak devori funksiyasi buzilishi orqali yuzaga kelishi mumkin. Natijalar ushbu xavfli guruhlar uchun glyukoza o‘zgaruvchanligini kamaytirish va oshqozon-ichak salomatligini yaxshilashga qaratilgan integratsiyalashgan metabolik va ekologik sog‘liqni saqlash choralari zarurligini ko‘rsatadi.

Kalit so‘zlar: glyukoza o‘zgaruvchanligi, ovqatdan keyingi giperglikemiya, oshqozon-ichak simptomlari, Janubiy Orolbo‘yi mintaqasi, metabolik yallig‘lanish, uzluksiz glyukoza monitoringi, ichak to‘sig‘ining buzilishi.

Аннотация. Постпрандиальные колебания уровня глюкозы, характеризующиеся быстрым повышением концентрации глюкозы в крови после приёма пищи, всё чаще рассматриваются как значимый фактор метаболической дисрегуляции и системного воспаления. Однако их влияние на состояние желудочно-кишечного тракта (ЖКТ) остаётся недостаточно изученным, особенно среди популяций, подверженных воздействию

экологических стрессоров, таких как население Южно-Аральского региона. Настоящее исследование было направлено на оценку взаимосвязи между суточной вариабельностью глюкозы и выраженностью симптомов со стороны ЖКТ в данной уязвимой популяции. Было проведено проспективное когортное наблюдательное исследование с участием 150 взрослых без установленного диагноза сахарного диабета, проживающих в Южно-Аральском регионе. В течение 14 дней осуществлялся непрерывный мониторинг глюкозы (НМГ) для количественной оценки колебаний глюкозы, определяемых как превышение уровня глюкозы более чем на 30 мг/дл от исходного значения в течение двух часов после приёма пищи. Симптомы со стороны ЖКТ оценивались еженедельно с помощью валидированной шкалы оценки гастроинтестинальных симптомов (ШОГС). Диетическое потребление изучалось с использованием расширенных частотных опросников, а воздействие факторов окружающей среды документировалось с помощью стандартизированных анкет. Анализ проводился с использованием многомерных линейных регрессионных моделей с учётом потенциальных смешивающих переменных. Среднее число суточных глюкозных пиков составило 3,8 ± 1,2. Повышенная частота глюкозных всплесков была статистически достоверно связана с увеличением общего балла ШОГС ($\beta = 0,45$; $p < 0,001$), особенно в доменах абдоминальной боли, вздутия живота и нарушения стула. Участники с более чем четырьмя всплесками глюкозы в сутки сообщали о почти двукратно большей выраженности симптомов ЖКТ по сравнению с участниками с менее выраженными колебаниями. Высокое потребление рафинированных углеводов положительно коррелировало с вариабельностью глюкозы ($r = 0,52$; $p < 0,001$). Воздействие загрязняющих веществ имело умеренное влияние на выраженность симптомов, но не демонстрировало прямой связи с глюкозными колебаниями. Частые постпрандиальные скачки глюкозы способствуют усилению гастроинтестинальной симптоматики у жителей Южно-Аральского региона, предположительно за счёт метаболического воспаления и нарушения кишечного барьера. Полученные результаты подчёркивают необходимость интегрированных метаболических и экологических стратегий, направленных на снижение вариабельности глюкозы и улучшение состояния ЖКТ в группах риска.

Ключевые слова: вариабельность глюкозы, постпрандиальная гипергликемия, гастроинтестинальные симптомы, Южно-Аральский регион, метаболическое воспаление, непрерывный мониторинг глюкозы, нарушение кишечного барьера.

Abstract. Postprandial glucose excursions, characterized by rapid increases in blood glucose levels following meals, are increasingly recognized as contributors to metabolic dysregulation and systemic inflammation. However, their specific impact on gastrointestinal (GI) health remains insufficiently characterized, especially in populations exposed to environmental stressors such as those in the South Aral region. This study aimed to evaluate the association between daily glucose variability and gastrointestinal symptomatology in this vulnerable population. A prospective observational cohort study was conducted involving 150 adult participants without diagnosed diabetes, residing in the South Aral region. Continuous glucose monitoring (CGM) over 14 days quantified glucose fluctuations, defined as postprandial spikes exceeding 30 mg/dL above baseline within two hours of meals. Gastrointestinal symptoms were assessed weekly via the validated Gastrointestinal Symptom Rating Scale (GSRS). Dietary intake was evaluated using detailed food frequency questionnaires (FFQ), and environmental exposures were documented through standardized surveys. Multivariate linear regression models adjusted for confounding variables. The cohort exhibited an average of 3.8 ± 1.2 daily glucose spikes. Increased glucose spike frequency was significantly correlated with higher total GSRS scores ($\beta = 0.45$, $p < 0.001$), with pronounced effects on domains of abdominal pain, bloating, and bowel irregularity. Participants with >4 spikes per day reported nearly double the GI symptom burden compared to those with fewer spikes. High intake of refined carbohydrates was positively associated with glucose variability ($r = 0.52$, $p < 0.001$).

Environmental pollutant exposure showed a modest exacerbation of symptoms but was not directly linked to glucose fluctuations. Frequent postprandial glucose spikes contribute to increased gastrointestinal symptomatology in the South Aral population, suggesting a pathophysiological link potentially mediated by metabolic inflammation and gut barrier dysfunction. These findings underscore the need for integrated metabolic and environmental health interventions aimed at reducing glucose variability and improving GI health in at-risk populations.

Key words: Glucose variability, postprandial hyperglycemia, gastrointestinal symptoms, South Aral region, metabolic inflammation, continuous glucose monitoring, gut barrier dysfunction.

Introduction. The prevalence of metabolic disorders characterized by impaired glucose regulation, including prediabetes and type 2 diabetes mellitus (T2DM), is rising globally, with significant public health implications [1]. Emerging evidence indicates that not only chronic hyperglycemia but also acute glycemic excursions, or glucose spikes, independently contribute to oxidative stress, systemic inflammation, and microvascular complications [2]. While the vascular and neural sequelae of glucose variability are well-documented, less attention has been given to the gastrointestinal (GI) tract, which serves as both a metabolic interface and immune organ.

The gastrointestinal mucosa is particularly vulnerable to fluctuations in glucose levels, which can disrupt epithelial tight junction integrity, alter gut motility, and induce dysbiosis [3,4]. These pathophysiological changes may manifest clinically as functional GI disorders, including irritable bowel syndrome (IBS), gastroparesis, and inflammatory bowel diseases (IBD) exacerbations.

The South Aral region represents a unique environmental and epidemiological context. Following the desiccation of the Aral Sea, the area has experienced profound ecological degradation, with increased dust-borne pollutants and compromised food security contributing to altered dietary patterns and heightened chronic disease risk [6]. These factors may potentiate the metabolic and gastrointestinal consequences of glucose dysregulation.

This study aims to elucidate the clinical impact of daily glucose spikes on gastrointestinal health in adults residing in the South Aral region, hypothesizing that higher glucose variability correlates with increased GI symptom burden, modulated by diet and environmental exposures.

Materials and methods. A prospective cohort study was conducted between January and June 2024. Participants aged 25–60 years were recruited via community health centers in the South Aral region. Inclusion criteria required residency in the region for ≥5 years and absence of diagnosed diabetes or chronic gastrointestinal diseases (e.g., Crohn's disease, ulcerative colitis). Exclusion criteria included current use of glucose-lowering or GI motility-modifying medications, pregnancy, and severe systemic illness. The study protocol was approved by the Institutional Review Board of the Central Asian Institute of Public Health (IRB #2023-07-15). Written informed consent was obtained from all participants. Participants were fitted with Dexcom G6 continuous glucose monitors (CGM), calibrated per manufacturer guidelines. Glucose data were collected every 5 minutes over a continuous 14-day period. Glucose spikes were operationally defined as a rise >30 mg/dL from preprandial baseline sustained within 2 hours post-meal [2]. GI symptoms were evaluated weekly using the validated Gastrointestinal Symptom Rating Scale (GSRS), covering domains of abdominal pain, reflux, indigestion, diarrhea, and constipation [5]. Scores range from 1 (no discomfort) to 7 (severe discomfort). Dietary intake was assessed via interviewer-administered food frequency questionnaires (FFQ), validated for Central Asian populations, focusing on carbohydrate quantity and quality (refined vs. complex) [7]. Participants completed a structured survey detailing exposure to regional environmental factors, including dust storms, proximity to industrial sites, and use of contaminated water sources [6]. Descriptive statistics characterized the cohort. Pearson correlation assessed relationships between glucose spike frequency, dietary variables, and GSRS scores. Multivariate linear regression models adjusted for age, sex, BMI, dietary carbohydrate intake, and environmental exposure indices. Statistical significance was set at $p < 0.05$. Analyses were performed using SPSS v27.0.

Results. The final sample (N=150) had a mean age of 43.2 ± 9.1 years, 54% female, mean BMI 26.8 ± 4.3 kg/m². Average daily carbohydrate intake was 270 ± 85 grams, with a high proportion (65%) consuming predominantly refined carbohydrates. Participants experienced a mean of 3.8 ± 1.2 glucose spikes daily. Stratifying by spike frequency (>4 vs. ≤4 spikes/day) revealed significant differences in GSRS scores: 2.9 ± 0.7 vs. 1.7 ± 0.5 respectively ($p < 0.001$). Significant positive correlations were observed between spike frequency and abdominal pain ($r = 0.52$, $p < 0.001$), bloating ($r = 0.46$, $p = 0.002$), diarrhea ($r = 0.37$, $p = 0.011$), and constipation ($r = 0.29$, $p = 0.032$). Refined carbohydrate intake correlated positively with spike frequency ($r = 0.52$, $p < 0.001$). Environmental exposure scores moderately correlated with GSRS ($r = 0.33$, $p = 0.021$) but showed no significant association with glucose variability ($r = 0.12$, $p = 0.34$). After adjustment, glucose spike frequency remained independently associated with total GSRS score ($\beta = 0.45$, 95% CI: 0.31–0.59, $p < 0.001$). Refined carbohydrate intake ($\beta = 0.28$, $p = 0.004$) and environmental exposure ($\beta = 0.22$, $p = 0.028$) also contributed to symptom severity but to a lesser extent.

Discussions. Our findings demonstrate a robust association between frequent daily postprandial glucose spikes and increased gastrointestinal symptom burden in adults residing in the South Aral region. This extends current knowledge of glucose variability's systemic impact to include clinically significant GI dysfunction.

Mechanistically, acute glucose excursions may induce oxidative stress and pro-inflammatory cytokine production, compromising intestinal epithelial barrier integrity and altering motility [2,3,4]. These effects could exacerbate symptoms such as abdominal pain, bloating, and altered bowel habits, as reflected by the GSRS findings.The region's environmental challenges—dust exposure and pollution—while not directly increasing glucose variability, appear to exacerbate GI symptoms, potentially through additive inflammatory pathways [6]. The predominance of refined carbohydrate consumption likely drives glucose spike frequency, underscoring dietary modification as a key intervention target [7].

Clinically, this study highlights the importance of monitoring glucose variability, beyond average glucose levels, to better understand and manage GI symptomatology, particularly in populations exposed to environmental and nutritional stressors. Continuous glucose monitoring offers an effective tool for identifying at-risk individuals and tailoring interventions. Limitations include the observational design, precluding causal inference, and the potential for unmeasured confounders. Future longitudinal and interventional studies are needed to elucidate causality and evaluate the effects of glucose modulation on GI outcomes.

Conclusion. In the South Aral region, frequent postprandial glucose spikes are independently associated with increased gastrointestinal symptoms, suggesting a pathophysiological role of glucose variability in GI dysfunction. These findings advocate for integrative metabolic and environmental health strategies aimed at reducing glucose fluctuations through dietary and lifestyle interventions to improve GI health in environmentally vulnerable populations.

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