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Editorial

Chrononutrition: An Emerging Pillar of Personalized Diabetes Management

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Diabetes mellitus is a major non-communicable disease, and its global prevalence continues to increase despite substantial advances in pharmacological therapies. According to the latest International Diabetes Federation (IDF) report, approximately 590 million adults were living with diabetes in 2024, and this number is predicted to increase by 45% by 2050. [1]. The limited success of conventional dietary guidelines, which primarily emphasize calorie restriction for individuals with obesity and diabetes and a balanced intake of macronutrients, particularly reduced consumption of refined carbohydrates, suggests that factors beyond conventional dietary recommendations may play an important role in improving glycemic control [2]. Recent evidence suggests that both the relative proportions of macronutrients within a meal and the timing of macronutrient consumption can significantly influence glycemic control [3]. These findings indicate that *when* to eat may be just as important as *what* and *how much* to eat in personalized diabetes management [4].

Chrononutrition, a branch of chronobiology, is an emerging nutritional approach that aligns dietary behaviors with the body's circadian rhythms, which regulate daily fluctuations in metabolic processes [4]. Incorporating chrononutrition into dietary interventions may be more effective than conventional dietary recommendations alone for the management. Unlike traditional approaches that primarily emphasize adequate intake of individual nutrients, chrononutrition also considers the timing and distribution of food intake to optimize metabolic outcomes [5].

Although the concept of chrononutrition emerged in the early 2000s, its clinical application has gained considerable attention since 2020, as reflected by the rapidly increasing number of publications. Current evidence suggests that glucose homeostasis and metabolic health are influenced by the complex interplay among chronotype, meal timing, meal frequency, macronutrient distribution, and the body's endogenous circadian rhythms. Consequently, chrononutrition expands traditional dietary recommendations by incorporating the timing of food intake into personalized nutritional strategies aimed at improving glycemic control [3].

Author's Biosketch

Nazli Namazi is an Associate Professor of Nutritional Sciences at the Endocrinology and Metabolism Research Institute (EMRI), affiliated with Tehran University of Medical Sciences (TUMS) in Tehran, Iran. Her research primarily focuses on the role of nutrition in diabetes and other non-communicable diseases. She was honored with the Outstanding Young Researcher Award at the National Razi Festival (Iran) in 2020 in recognition of her contributions to the scientific community. Additionally, she serves as a reviewer and Section Editor for several international journals specializing in nutrition and complementary therapies.

Findings from the cross-sectional Chrono-DM™ study demonstrated that the timing of daily meals is significantly associated with glycemic status in Malaysian adults with prediabetes. Delaying the first meal until after 10:00 a.m. was associated with a 70% higher likelihood of having an HbA1c level ≥5.7%. Similarly, consuming the last meal after 8:00 p.m. was associated with a 2.6-fold higher risk of elevated HbA1c compared with eating the last meal earlier [6]. In a cross-sectional analysis of middle-aged Caucasian adults, a higher carbohydrate intake at breakfast was associated with a 25% lower prevalence of type 2 diabetes (T2DM). In contrast, higher lipid intake at breakfast was associated with a 13% increase in the prevalence of T2DM for each one standard deviation increase in fat intake [7]. Based on the Maastricht Study in the Netherlands, skipping breakfast was associated with higher fasting blood sugar (FBS) levels in participants with prediabetes, while being associated with lower 2-hour postprandial glucose levels. In addition, greater meal irregularity was associated with higher FBS concentrations. Among individuals with T2DM, greater meal irregularity was associated with elevated HbA1c levels [8]. Another study also reported that consuming carbohydrates during periods of elevated endogenous melatonin levels, as commonly occurs with late-night eating, impairs glucose tolerance, particularly in carriers of the MTNR1B G risk allele, likely due to impaired insulin secretion [9]. These findings suggest that glycemic responses to meal timing may vary according to an individual's genetic background, highlighting the potential for personalized chrononutrition.

The health benefits of chrononutrition are thought to arise from aligning eating behaviors with the body's intrinsic circadian rhythms. At the center of this system is the suprachiasmatic nucleus, which synchronizes peripheral clocks in key metabolic organs, including the liver, skeletal muscle, pancreas, and adipose tissue. This coordinated network regulates the daily rhythmic expression of genes involved in insulin secretion and sensitivity, glucose transport, hepatic glucose production, and overall energy metabolism [4]. Therefore, meal consumption in harmony with these biological rhythms supports metabolic homeostasis, whereas circadian disruption caused by behaviors such as late-night eating, breakfast skipping, or irregular meal patterns can impair insulin action, alter clock gene function, worsen postprandial glycemic responses, and increase the risk of T2DM [4]. The Morningness–Eveningness Questionnaire (MEQ) is one of the most widely used instruments for assessing an individual's chronotype. Individuals with a morning chronotype may benefit more from an earlier time-restricted eating window than from a later eating window. However, the optimal timing and duration of the eating window for each chronotype have not yet been clearly established [10]. But chrononutrition can be integrated with digital health technologies to provide more personalized dietary interventions. Continuous glucose monitoring (CGM), wearable devices, and AI-based applications enable real-time assessment of metabolic and circadian patterns. These technologies can help nutritionists and physicians deliver more personalized and effective dietary recommendations [11].

Future chrononutrition approach should move beyond a one-size-fits-all strategy by accounting for individual differences in circadian biology, genetic background, and gut microbiome composition. Wider implementation will require scalable, culturally adaptable digital tools and greater awareness among healthcare professionals, enabling dietary counseling that considers not only *what* and *how much* to eat, but also *when* to eat. However, the cost of personalized assessments is a main challenge that may limit the feasibility and accessibility of chrononutrition-based interventions, particularly in low-income countries.

Overall, chrononutrition has emerged as a key component of personalized diabetes management. Growing evidence suggests that aligning meal timing with circadian rhythms may improve glycemic control and metabolic health. Advances in digital health technologies, combined with a better understanding of circadian biology, are creating new opportunities to translate chrononutrition into clinical practice. However, further high-quality clinical trials and cohort studies across diverse populations are needed to clarify optimal and individualized recommendations. Additionally, the cost and accessibility of digital health technologies may limit the widespread implementation of personalized chrononutrition in routine clinical care.

Competing Interests

None.

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