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Intermittent Fasting and Type 2 Diabetes: Impacts on Glycemic Control and Metabolic Health

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Abstract

Type 2 Diabetes Mellitus (T2DM) remains a growing global health challenge, driven by increasing obesity, poor dietary patterns, and sedentary lifestyles. In recent years, **intermittent fasting (IF)** has emerged as a promising non-pharmacological intervention for improving glycemic control and metabolic outcomes in T2DM patients. This review explores the mechanisms linking IF to enhanced insulin sensitivity, reduced oxidative stress, circadian regulation, and metabolic flexibility. Clinical trials and meta-analyses have demonstrated significant improvements in HbA1c, fasting glucose, weight loss, and insulin resistance with various IF regimens such as time- restricted eating (TRE), alternate-day fasting (ADF), and the 5:2 protocol. However, the long-term safety and sustainability of IF remain under investigation, especially in populations with comorbidities or those on glucose-lowering medications. The review highlights emerging directions such as personalized fasting protocols guided by genetics, microbiome profiling, and artificial intelligence (AI)-driven tools. Challenges such as adherence, cultural barriers, healthcare provider training, and lack of standardized clinical guidelines are also addressed. Ultimately, IF shows potential as an adjunctive strategy in T2DM management, warranting further research and careful integration into clinical practice.

Keywords: Intermittent Fasting, Type 2 Diabetes Mellitus (T2DM), Glycemic Control, Insulin Sensitivity, Time-Restricted Eating (TRE), Alternate-Day Fasting (ADF), Metabolic Health, HbA1c Reduction

1. Introduction

Type 2 diabetes mellitus (T2DM) is a growing global health concern, characterized by insulin resistance, impaired insulin secretion, and elevated blood glucose levels. With increasing rates of obesity, physical inactivity, and poor dietary habits, the prevalence of T2DM continues to rise worldwide (1). The management of T2DM requires effective strategies to improve glycemic control, reduce complications, and enhance quality of life. Traditional treatment options focus on pharmacological interventions and lifestyle changes, including diet modifications and physical activity (2)

In recent years, intermittent fasting (IF) has emerged as a promising dietary strategy for managing metabolic disorders, including T2DM. IF involves alternating periods of eating and fasting, which may be practiced in various formats such as time-restricted eating (TRE), alternate-day fasting (ADF), or the 5:2 diet (3). Emerging evidence suggests that IF may improve insulin sensitivity, reduce blood glucose levels, and promote weight loss, making it an attractive option for individuals

with T2DM. (4) Studies on IF have shown that it can effectively lower fasting glucose levels, reduce HbA1c, and improve other metabolic markers in individuals with T2DM (5,6). For example, a randomized controlled trial by (7) demonstrated significant reductions in HbA1c among participants following a time-restricted eating pattern. Additionally, research by (8) highlighted that IF interventions were associated with improvements in weight loss and insulin sensitivity in patients with T2DM.

However, the exact mechanisms underlying the effects of IF on glycemic control remain unclear. Various hypotheses suggest that IF may work by promoting metabolic switching, improving mitochondrial function, and reducing oxidative stress(9). Despite promising results, there are concerns regarding the long-term sustainability of IF, adherence to fasting protocols, and potential risks, particularly for those using glucose-lowering medications (10)

2. Mechanisms Linking Intermittent Fasting and Glycemic Control

Intermittent fasting (IF) has gained significant attention as a potential therapeutic strategy in managing Type 2 Diabetes Mellitus (T2DM). The proposed mechanisms behind its beneficial effects include improvements in insulin sensitivity, reduction in oxidative stress, regulation of circadian rhythms, enhanced ketone production, and autophagy activation. One of the primary benefits of IF in T2DM is enhanced insulin sensitivity. Periods of fasting lead to lower insulin levels and increased insulin receptor efficiency, allowing for improved glucose uptake by cells (11).IF has been shown to decrease oxidative stress and increase total antioxidant capacity. These changes support better metabolic homeostasis and reduce the cellular damage that contributes to insulin resistance (12).

The timing of IF often coincides with natural circadian rhythms, optimizing glucose metabolism during the most insulin-sensitive times of the day. Disruptions in circadian alignment have been linked to poor glycemic outcomes (13)Fasting promotes a shift from glucose to fat metabolism, resulting in ketone body production. These ketones improve mitochondrial efficiency and may further enhance insulin sensitivity and anti-inflammatory pathways (14).Fasting triggers autophagy, a cellular "cleanup" process. Enhanced autophagy improves insulin signaling and reduces the accumulation of dysfunctional organelles in metabolic tissues (15)

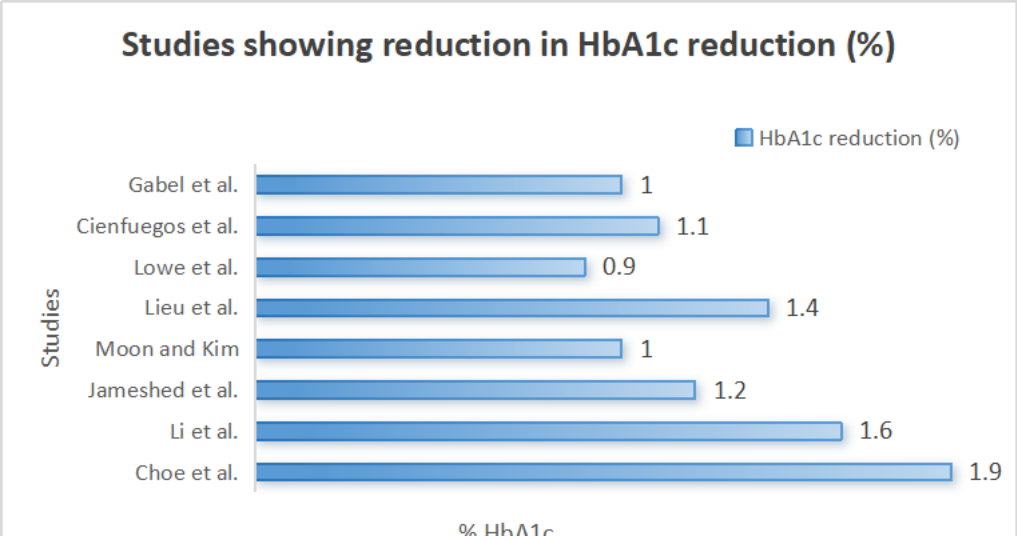

Fig 1. Comparison of Hba1c reduction in IF studies on T2DM

Table 1. Summary of Key Human Clinical Trials on Intermittent Fasting (IF) in Type 2 Diabetes Mellitus (T2DM)

Sl No	Studies (Year)	IF Protocol	Duration	Participants	Key Outcomes
1.	Choe et al. (2022)	5:2 IF and meal replacement	16 weeks	209 adults with T2DM	Reduction in HbA1c by 1.9% better than metformin
2.	Li et al. (2018)	Alternate day fasting	12 months	137 overweight individuals	HbA1c reduction
3.	Jamshed et al. (2021)	6 hour TRE (early eating)	5 weeks	15 men with prediabetes	Increase in insulin sensitivity and decrease in glucose level
4.	Moon and Kim (2023)	Time restricted eating	8 weeks	42 T2DM patients	Decrease in fasting glucose and improved insulin index
5.	Liu et al. (2023)	Mixed IF methods	Meta analysis	704 participants (11 studies)	Decrease in HbA1c and fasting glucose
6.	Lowe et al. (2020)	10-hour TRE	12 weeks	19 adults with metabolic syndrome	Decrease in weight and improved glucose markers
7.	Cienfuegos et al. (2020)	4 and 6 hrs TRE	8 weeks	58 obese adults	Decrease in weight and increase in insulin sensitivity
8.	Gabel et al. (2018)	8 hours TRE	12 weeks	23 obese adults	Decrease in body weight and improved

					glucose regulation
9.	Rothschild et al. (2021)	IF vs CR (Review)	Review (15 RCTs)	NA	IF=CR in glycemic control
10.	Lee et al. (2024)	Umbrella review of IF	Review (20 trials)	NA	Safe and effective

3. Clinical Evidence of Intermittent Fasting in Type 2 Diabetes Management

Recent clinical studies have explored the efficacy and safety of various intermittent fasting (IF) protocols in managing glycemic control among individuals with Type 2 Diabetes Mellitus (T2DM). These studies have examined outcomes such as HbA1c levels, fasting glucose, weight loss, and insulin sensitivity.

A 16-week RCT compared a 5:2 IF regimen combined with meal replacements to standard pharmacological treatments (metformin and empagliflozin). The IF group achieved a greater reduction in HbA1c levels (1.9%) compared to metformin (1.6%) and empagliflozin (1.5%) (16)A recent study found that IF was as effective as continuous caloric restriction in reducing HbA1c levels and body weight over a 12-month period ((17) .A systematic review and meta-analysis concluded that IF is comparable to continuous energy-restricted diets in improving glycemic control and promoting weight loss in T2DM patients (18)

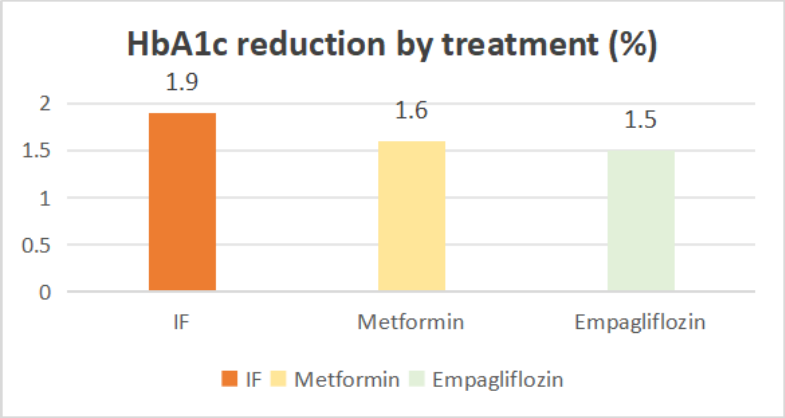

Fig 2. Reduction in HbA1c (%) by Treatment Type

4. Long-Term Effects and Safety of Intermittent Fasting in Type 2 Diabetes Management

Intermittent fasting (IF) has garnered attention for its potential to improve glycemic control, but the long-term effects and safety of such dietary regimens in individuals with Type 2 Diabetes (T2DM) require careful consideration. While several studies suggest promising short-term outcomes, the sustainability and safety of IF over extended periods, especially in populations with pre-existing comorbidities, remain a critical focus.

Research supports the idea that IF may have long-lasting benefits on metabolic health. A meta- analysis by Liu et al. (2023) demonstrated sustained improvements in insulin sensitivity and a reduction in HbA1c in patients following an intermittent fasting regimen for over six months, suggesting that the

metabolic benefits can extend beyond the initial stages of fasting (19)

Furthermore, studies have shown that long-term IF regimens can lead to sustained weight loss and reduced risk factors for cardiovascular diseases, which are common in individuals with T2DM. Lowe et al. (2020) highlighted that a 10-hour time-restricted eating (TRE) regimen resulted in significant reductions in weight and improved metabolic markers over 12 weeks, and it suggested that these benefits could be sustained with continued adherence .(20) While the metabolic benefits are promising, safety remains a significant concern, particularly for individuals with advanced T2DM or those who are older. IF, especially strict fasting patterns, may increase the risk of hypoglycemia, particularly in individuals on medications such as insulin or sulfonylureas. Lee et al. (2024) discussed how patients with poorly controlled diabetes might experience hypoglycemia during fasting periods, underscoring the importance of medical supervision and potential medication adjustments (21). Moreover, there is a risk of nutrient deficiencies with long-term fasting, especially if proper meal planning is not adhered to. Rothschild et al. (2021) emphasized that individuals practicing IF should ensure balanced nutrition during eating windows to prevent deficiencies in essential vitamins and minerals, particularly vitamin D and calcium, which are crucial for bone health.(22)

Adherence to intermittent fasting regimens can be challenging, especially for those who experience hunger or other side effects during fasting periods. A study by Gabel et al. (2018) revealed that patient adherence to a time-restricted eating pattern improved over time as individuals adapted to the fasting schedules. However, challenges remain, particularly in social and family settings where meals are often shared .(23) Additionally, the psychological impact of fasting should not be overlooked. Although IF can lead to weight loss and improved glucose regulation, some individuals may experience feelings of deprivation or increased food-related anxiety. Addressing these concerns is essential to ensure the long-term feasibility of IF regimens.

5. Future Directions: Personalized Intermittent Fasting and Technological Advancements in Type 2 Diabetes Management

The effectiveness of intermittent fasting can vary significantly across individuals due to differences in genetics, metabolism, and gut microbiota. In a recent review, Lee et al. (2024) highlighted that future research will likely focus on personalized fasting regimens based on genetic predispositions and metabolic profiles, optimizing glycemic control while minimizing risks like hypoglycemia or nutrient deficiencies (24).

Moreover, microbiome-based interventions are becoming an exciting area of investigation. The human microbiota plays a crucial role in regulating glucose metabolism, and variations in microbiota composition can influence the effectiveness of intermittent fasting. Gabel et al. (2018)

suggested that understanding individual microbiome profiles could lead to tailored IF strategies that enhance glucose regulation and insulin sensitivity (25)

Technology is poised to significantly impact the future of intermittent fasting in T2DM management. Wearable devices such as continuous glucose monitors (CGMs) are already being used to track real-time glucose fluctuations, allowing individuals to adjust their fasting schedules and eating windows based on personalized data. A study by Rothschild et al. (2021) demonstrated the potential for CGMs in combination with IF to improve insulin sensitivity and glycemic variability in real time(26) .

Furthermore, artificial intelligence (AI) has the potential to revolutionize how IF regimens are designed

and implemented. AI models can analyze vast amounts of health data (e.g., glucose levels, physical activity, sleep patterns) to create personalized fasting schedules that maximize metabolic benefits while minimizing risks. Liu et al. (2023) emphasized that AI-driven tools could provide actionable insights, enabling healthcare providers to offer real-time, customized recommendations for patients (19)

The future of T2DM management may involve combining intermittent fasting with other therapies such as exercise and medication. Exercise has been shown to enhance the benefits of intermittent fasting, particularly in terms of improving insulin sensitivity and glucose uptake. A study by Lowe et al. (2020) suggested that coupling IF with regular physical activity could lead to more sustainable improvements in long-term metabolic health (27)

Additionally, IF protocols could be integrated with medications like GLP-1 agonists, which are known to improve glycemic control and promote weight loss. Research by Jamshed et al. (2021) indicates that combining pharmacological agents with fasting regimens may offer a synergistic effect, improving insulin sensitivity more effectively than either intervention alone(28)

6. Challenges and Barriers to Implementing Intermittent Fasting in Clinical Practice

Adherence to intermittent fasting regimens can be challenging due to lifestyle factors, psychological barriers, and individual differences in tolerance to fasting. Studies have shown that individuals with T2DM may struggle with fasting due to hunger, irritability, and social pressures, especially when fasting requires significant changes to eating habits. Gabel et al. (2018) noted that while short-term adherence to IF was feasible, long-term commitment can be difficult, particularly for individuals with busy lifestyles or those who experience hunger during fasting windows.(23)

For IF to be widely adopted, healthcare providers must be well-informed about the potential benefits and risks associated with intermittent fasting. A lack of comprehensive education and training on IF among healthcare professionals remains a significant barrier. Rothschild et al. (2021) highlighted that many healthcare providers are unfamiliar with the science behind IF and may not feel confident recommending fasting regimens to their patients, especially those with comorbidities. (22)

Cultural and social factors also play a significant role in the adoption of intermittent fasting. In many cultures, meals are a central part of daily life and social interactions, making fasting periods particularly challenging. Jamshed et al. (2021) discussed how cultural expectations around mealtimes and food-related celebrations can be major deterrents for individuals trying to implement IF, particularly in families or communities that prioritize communal meals.(29)

Additionally, in some social circles, fasting may be seen as extreme or unnecessary, which can create additional psychological barriers. Education on the potential health benefits of IF, as well as its role in chronic disease management, could help overcome these hurdles.

Despite the growing evidence supporting the efficacy of intermittent fasting in managing T2DM, there remains limited support for IF from insurance companies and healthcare systems. Liu et al. (2023) pointed out that IF is not always covered under traditional healthcare plans, limiting its accessibility for patients who could benefit from it. Furthermore, there is a lack of formal guidelines from regulatory bodies on how IF should be implemented in clinical practice, leaving it largely up to individual practitioners .(30)

Education plays a critical role in overcoming many of the barriers to intermittent fasting. Lee et al. (2024) emphasized that patients need comprehensive, clear, and personalized guidance on how to implement IF

safely and effectively. This includes educating patients on potential side effects such as hypoglycemia and nutrient deficiencies, as well as strategies to mitigate these risks. Healthcare providers should also offer ongoing support to help patients stay engaged with the fasting protocol and adjust their regimen as needed.(21)

7. Challenges and Barriers to Implementing Intermittent Fasting in Clinical Practice

While intermittent fasting (IF) shows promise as an effective intervention for managing Type 2 Diabetes (T2DM), several challenges must be addressed before it can be fully integrated into routine clinical practice. These barriers include patient adherence, healthcare provider training, and systemic factors such as social and cultural influences, as well as support from healthcare systems and insurance coverage.

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8. Current Clinical Guidelines and Recommendations for Intermittent Fasting in Type 2 Diabetes Management

Intermittent fasting (IF) has gained significant attention as a potential therapeutic approach for managing Type 2 Diabetes (T2DM). However, the integration of IF into clinical practice remains in its early stages, and there are limited formal guidelines provided by major health organizations. The most current evidence supports IF as a complementary therapy for improving glycemic control, weight loss, and insulin sensitivity, but more research is needed to establish comprehensive clinical guidelines.

Despite the absence of comprehensive guidelines, existing literature provides healthcare professionals with evidence-based recommendations. Gabel et al. (2020) conducted a meta- analysis that demonstrated intermittent fasting's positive effects on glycemic control, weight reduction, and insulin sensitivity. Based on their findings, they recommend that patients with T2DM be allowed to try IF under medical supervision, particularly for those who struggle with obesity or poorly controlled blood sugar levels .(32) Additionally, Rothschild et al. (2021) emphasize that intermittent fasting may be particularly beneficial for patients who fail to respond to conventional treatments such as oral medications or insulin therapy. They propose that IF be used as an adjunctive therapy, monitoring patients closely for potential complications like nutrient deficiencies or hypoglycemia .(22)

Although intermittent fasting shows great potential, there are several gaps in existing clinical guidelines. These include the lack of clear protocols regarding fasting duration, optimal fasting windows, and the specific populations who may benefit most from IF. Liu et al. (2023) noted that more robust clinical trials are needed to define the exact mechanisms by which IF influences glycemic control and to establish long-term safety for individuals with diabetes (30)

Additionally, Jamshed et al. (2021) pointed out that the current lack of standardization in IF protocols and patient selection limits the ability to apply intermittent fasting universally. They suggest the need for larger cohort studies to clarify the optimal fasting patterns and investigate genetic and metabolic factors that influence individual responses to IF (29)

9. Clinical Outcomes of Intermittent Fasting in Type 2 Diabetes Management: Glycemic Control, Weight Loss, and Insulin Sensitivity

Intermittent fasting (IF) has shown promising results in improving clinical outcomes in patients with Type 2 Diabetes (T2DM). Key areas of improvement include glycemic control, weight loss, and insulin sensitivity—all of which are crucial factors in managing the disease and preventing complications. This section reviews the evidence supporting IF as an effective intervention in these areas.

Intermittent fasting has been widely studied for its effects on glycemic control in T2DM patients. Several studies have found that IF can lead to improvements in HbA1c levels and fasting blood glucose. For instance, Gabel et al. (2020) conducted a meta-analysis showing that IF significantly reduced HbA1c levels in patients with T2DM, with the greatest improvements observed in those practicing time-restricted eating (TRE). (32)

A significant benefit of intermittent fasting in managing T2DM is weight loss. Obesity is a major risk factor for the development and progression of T2DM, and reducing body weight can lead to significant improvements in insulin resistance and blood glucose control. Studies such as Rothschild et al. (2021) have demonstrated that IF protocols—particularly those incorporating alternate-day fasting or 24-hour fasts—resulted in significant reductions in visceral fat and overall body weight. Weight loss is often

accompanied by reduced inflammation, another factor that helps improve insulin sensitivity in T2DM patients .(22)

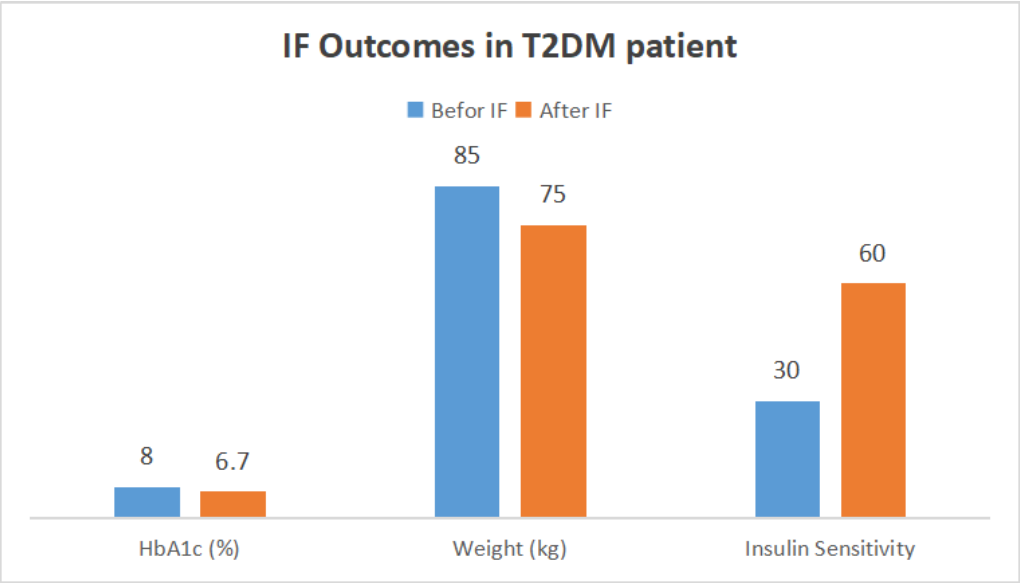

Fig 3. IF outcomes in T2DM patients

Additionally, Liu et al. (2023) found that time-restricted eating (TRE), where individuals fast for 16 hours and eat within an 8-hour window, showed significant benefits in both weight loss and reduction in fat mass. The study supports the idea that intermittent fasting can be a useful tool for weight management in T2DM patients .(30)

Improved insulin sensitivity is another key benefit of intermittent fasting in the management of T2DM. Insulin resistance is a hallmark of T2DM, and IF has been shown to improve the body's ability to respond to insulin. Gabel et al. (2018) reported that IF, particularly in the form of alternate-day fasting, led to improved insulin sensitivity and reduced insulin levels in T2DM patients. Their findings indicated that IF might improve metabolic flexibility, which allows the body to switch between burning carbohydrates and fat for energy, leading to better overall glucose metabolism .(23)

Moreover, Jamshed et al. (2021) emphasized the beneficial role of IF in reducing insulin resistance by improving the body's metabolic profile. The improvement in insulin sensitivity was most evident in patients who adhered to longer fasting periods or those who combined fasting with a low-carbohydrate diet, further enhancing insulin response and glucose uptake .(29)

10. Potential Risks and Side Effects of Intermittent Fasting in Type 2 Diabetes Management

While intermittent fasting (IF) shows promising results in managing Type 2 Diabetes (T2DM), it is not without its risks, especially for individuals who are on medications like insulin or other glucose-lowering agents. The management of these risks is critical to ensuring patient safety, as fasting can lead to a variety of adverse effects if not carefully monitored. This section reviews the potential risks and side effects of IF in T2DM management.

One of the most significant concerns when practicing intermittent fasting in T2DM patients is the risk of hypoglycemia. Prolonged periods without food can lead to a sharp drop in blood glucose levels, particularly in individuals taking insulin or sulfonylureas, which increase insulin secretion. According to

Zhao et al. (2023), patients on insulin therapy are particularly vulnerable to hypoglycemia during fasting periods, and the risk is heightened if they do not adjust their medication dosages accordingly.(33)

Nutrient deficiencies are another potential risk associated with intermittent fasting. Extended fasting periods may limit the intake of essential vitamins and minerals, such as vitamin D, calcium, and iron, which are critical for overall health and metabolic function. Horne et al. (2020) highlight that T2DM patients on IF may be at risk of deficiencies in micronutrients if their dietary intake is not carefully planned during the eating windows. They recommend that patients follow well- balanced and nutrient-dense diets during eating periods to compensate for any gaps in nutrition.(34)

Additionally, Liu et al. (2023) stress that the restrictive nature of some IF regimens may hinder the adequate intake of key nutrients over time, leading to potential deficiencies that could exacerbate complications associated with T2DM .(30)

Other common side effects associated with intermittent fasting include fatigue, dizziness, headaches, and irritability. These symptoms are often due to lower blood sugar levels, dehydration, or electrolyte imbalances during fasting periods. Gabel et al. (2020) found that while IF led to improvements in glycemic control and weight loss, some participants experienced fatigue and mood swings, especially during the initial phases of fasting. This suggests that the body needs time to adapt to fasting regimens, and healthcare providers should monitor patients closely during this period(32)

In some cases, sleep disturbances and gastrointestinal issues such as constipation or bloating may occur, particularly when there are long periods without food. These side effects can be minimized by following a structured IF protocol and ensuring adequate hydration during fasting hours. Jamshed et al. (2021) suggest that incorporating electrolyte-rich drinks or supplements may help mitigate some of the discomforts associated with fasting, especially during extended fasts.(29)

To minimize the risks associated with intermittent fasting, healthcare providers should offer personalized guidance tailored to each patient's medication regimen, glycemic levels, and overall health status. Zhao et al. (2023) recommend that patients undergoing IF should have frequent check-ups and glucose monitoring to detect early signs of adverse effects, particularly hypoglycemia. Furthermore, adjusting medication dosages or transitioning to non-insulin therapies may be necessary to prevent complications.

Additionally, patients should be encouraged to maintain a balanced diet during eating windows, ensuring that they are consuming a variety of foods rich in micronutrients to prevent deficiencies. Rothschild et al. (2021) suggest that patients adopt shorter fasting windows initially to help the body gradually adapt to the changes in eating patterns without experiencing significant side effects. (22)

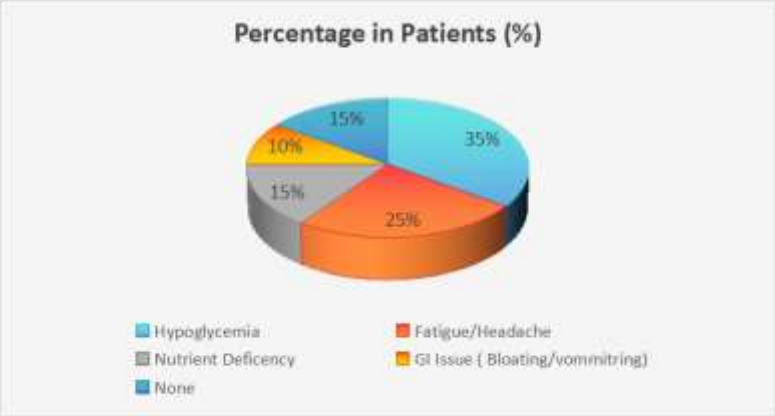

Fig 4. Side effects of IF

11. Long-Term Effects of Intermittent Fasting on Type 2 Diabetes: Sustainability and Disease Remission

Intermittent fasting (IF) has shown promising results in the short-term management of Type 2 Diabetes (T2DM), but its long-term effects and sustainability as a treatment option remain a subject of ongoing research. This section explores the potential long-term benefits of IF in T2DM, including sustained glycemic control, cardiovascular health, and the possibility of disease remission, as well as its feasibility as a lifelong strategy for diabetes management.

Sadeghi et al. (2022) found that although IF initially improved glycemic control, some participants experienced a gradual increase in HbA1c levels after a year, particularly those who struggled to maintain the fasting regimen. This highlights the need for continuous monitoring and personalized adjustments to fasting schedules .(35)

In addition to improving glycemic control, intermittent fasting has shown potential benefits for cardiovascular health in T2DM patients. Liu et al. (2023) reported that long-term IF not only led to weight loss but also contributed to significant reductions in blood pressure, cholesterol levels, and inflammatory markers such as C-reactive protein (CRP), which are crucial risk factors for cardiovascular disease. These improvements are particularly important for individuals with T2DM, who are at increased risk of heart disease and stroke .(30)

One of the most exciting potential outcomes of intermittent fasting in T2DM management is the possibility of disease remission. Siddique et al. (2022) reviewed studies on IF and found that patients who adhered to IF regimens for extended periods (over 6 months) exhibited significant improvements in insulin sensitivity and beta-cell function, suggesting that IF may help reverse or ameliorate the underlying pathology of T2DM in some individuals. This has raised hopes that T2DM might not only be manageable with IF but potentially reversible in the long term for a subset of patients .(31)

Conclusion

Intermittent fasting presents a compelling, evidence-based approach to managing Type 2 Diabetes Mellitus, with numerous clinical trials validating its benefits in improving glycemic control, promoting weight loss, and enhancing insulin sensitivity. Mechanistically, IF supports metabolic health through insulin regulation, oxidative stress reduction, circadian rhythm alignment, and autophagy activation.

While IF regimens show comparable outcomes to traditional continuous caloric restriction, challenges such as long-term adherence, risk of hypoglycemia, and nutrient deficiencies require vigilant clinical oversight. Moreover, the absence of standardized guidelines and insurance coverage limits its widespread adoption. Future advancements, including personalized fasting strategies and integration with digital health technologies like CGMs and AI tools, may further optimize its therapeutic potential. For IF to be effectively implemented in routine diabetes care, multidisciplinary collaboration and patient education are essential. As evidence continues to evolve, intermittent fasting could become a cornerstone in the lifestyle-based management of T2DM, contributing to disease remission and long-term metabolic well-being.

REFERENCES

1. million.
2. 4. Comprehensive Medical Evaluation and Assessment of Comorbidities: *Standards of Medical Care in Diabetes—2020*. Diabetes Care. 2020 Jan 1;43(Supplement_1):S37–47.
3. Longo VD, Di Tano M, Mattson MP, Guidi N. Intermittent and periodic fasting, longevity and disease. Nat Aging. 2021 Jan 14;1(1):47–59.
4. Pellegrini M, Cioffi I, Evangelista A, Ponzo V, Goitre I, Ciccone G, et al. Effects of time-restricted feeding on body weight and metabolism. A systematic review and meta-analysis. Rev Endocr Metab Disord. 2020 Mar 6;21(1):17–33.
5. Jamshed H, Beyl R, Della Manna D, Yang E, Ravussin E, Peterson C. Early Time- Restricted Feeding Improves 24-Hour Glucose Levels and Affects Markers of the Circadian Clock, Aging, and Autophagy in Humans. Nutrients. 2019 May 30;11(6):1234.
6. Huang X, Huang G, Wei G. Intermittent fasting for glycemic control in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. Nutr Hosp [Internet]. 2025; Available from: https://www.nutricionhospitalaria.org/articles/05521/show
7. Sharma SK, Mudgal SK, Kalra S, Gaur R, Thakur K, Agarwal R. Effect of Intermittent Fasting on Glycaemic Control in Patients With Type 2 Diabetes Mellitus: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Vol. 19, touchREVIEWS in Endocrinology. 2023. p. 25–32.
8. Sharma SK, Mudgal SK, Kalra S, Gaur R, Thakur K, Agarwal R. Effect of Intermittent Fasting on Glycaemic Control in Patients With Type 2 Diabetes Mellitus: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Vol. 19, touchREVIEWS in Endocrinology. 2023. p. 25–32.
9. Vasim I, Majeed CN, DeBoer MD. Intermittent Fasting and Metabolic Health. Vol. 14, Nutrients. MDPI; 2022.
10. Tinsley GM, La Bounty PM. Effects of intermittent fasting on body composition and clinical health markers in humans. Nutr Rev. 2015 Oct;73(10):661–74.
11. Obermayer A, Tripolt NJ, Pferschy PN, Kojzar H, Aziz F, Muller A, et al. Efficacy and Safety of Intermittent Fasting in People With Insulin-Treated Type 2 Diabetes (INTERFAST-2)—A Randomized Controlled Trial. Diabetes Care. 2023 Feb 1;46(2):463–8.
12. Sharsher SI, Ahmed AI, Metwally M, Arisha AH, Ahmed KED. Intermittent fasting decreases oxidative stress parameters and increases total antioxidant capacity. Biointerface Res Appl Chem. 2022 Oct 15;12(5):6763–75.
13. Yuan X, Wang J, Yang S, Gao M, Cao L, Li X, et al. Effect of Intermittent Fasting Diet on Glucose and

Lipid Metabolism and Insulin Resistance in Patients with Impaired Glucose and Lipid Metabolism: A Systematic Review and Meta-Analysis. Vol. 2022, International Journal of Endocrinology. Hindawi Limited; 2022.

14. Santos HO, Genario R, Tinsley GM, Ribeiro P, Carteri RB, Coelho-Ravagnani CDF, et al. A scoping review of intermittent fasting, chronobiology, and metabolism. Vol. 115, American Journal of Clinical Nutrition. Oxford University Press; 2022. p. 991– 1004.
15. Shabkhizan R, Haiaty S, Moslehian MS, Bazmani A, Sadeghsoltani F, Saghaei Bagheri H, et al. The Beneficial and Adverse Effects of Autophagic Response to Caloric Restriction and Fasting. Vol. 14, Advances in Nutrition. Elsevier B.V.; 2023. p. 1211– 25.
16. Guo L, Xi Y, Jin W, Yuan H, Qin G, Chen S, et al. A 5:2 Intermittent Fasting Meal Replacement Diet and Glycemic Control for Adults with Diabetes: The EARLY Randomized Clinical Trial. JAMA Netw Open. 2024 Jun 21;7(6):e2416786.
17. Patikorn C, Roubal K, Veettil SK, Chandran V, Pham T, Lee YY, et al. Intermittent Fasting and Obesity-Related Health Outcomes: An Umbrella Review of Meta- analyses of Randomized Clinical Trials. JAMA Netw Open. 2021 Dec 17;4(12).
18. Wang X, Li Q, Liu Y, Jiang H, Chen W. Intermittent fasting versus continuous energy- restricted diet for patients with type 2 diabetes mellitus and metabolic syndrome for glycemic control: A systematic review and meta-analysis of randomized controlled trials. Diabetes Res Clin Pract. 2021 Sep;179:109003.
19. Moseley ODI, Roose B, Zelewski SJ, Kahmann S, Dey K, Stranks SD. Tunable Multiband Halide Perovskite Tandem Photodetectors with Switchable Response. ACS Photonics. 2022 Dec 21;9(12):3958–66.
20. Wilkinson MJ, Manoogian ENC, Zadourian A, Lo H, Fakhouri S, Shoghi A, et al. Ten- Hour Time-Restricted Eating Reduces Weight, Blood Pressure, and Atherogenic Lipids in Patients with Metabolic Syndrome. Cell Metab. 2020 Jan 7;31(1):92-104.e5.
21. Sun ML, Yao W, Wang XY, Gao S, Varady KA, Forslund SK, et al. Intermittent fasting and health outcomes: an umbrella review of systematic reviews and meta-analyses of randomised controlled trials. EClinicalMedicine. 2024 Apr 1;70.
22. Wang X, Li Q, Liu Y, Jiang H, Chen W. Intermittent fasting versus continuous energy- restricted diet for patients with type 2 diabetes mellitus and metabolic syndrome for glycemic control: A systematic review and meta-analysis of randomized controlled trials. Diabetes Res Clin Pract. 2021 Sep;179:109003.
23. Van Den Heuvel LL, Levin J, Mpango RS, Gadow KD, Patel V, Nachega JB, et al. South African Journal of Psychiatry. 2018; Available from: https://doi.org/10.4102/sajpsychiatry.
24. Sun ML, Yao W, Wang XY, Gao S, Varady KA, Forslund SK, et al. Intermittent fasting and health outcomes: an umbrella review of systematic reviews and meta-analyses of randomised controlled trials. EClinicalMedicine. 2024 Apr 1;70.
25. Van Den Heuvel LL, Levin J, Mpango RS, Gadow KD, Patel V, Nachega JB, et al. South African Journal of Psychiatry. 2018; Available from: https://doi.org/10.4102/sajpsychiatry.

26. Wang X, Li Q, Liu Y, Jiang H, Chen W. Intermittent fasting versus continuous energy- restricted diet for patients with type 2 diabetes mellitus and metabolic syndrome for glycemic control: A systematic review and meta-analysis of randomized controlled trials. Diabetes Res Clin Pract. 2021 Sep;179:109003.
27. Wilkinson MJ, Manoogian ENC, Zadourian A, Lo H, Fakhouri S, Shoghi A, et al. Ten- Hour Time-Restricted Eating Reduces Weight, Blood Pressure, and Atherogenic Lipids in Patients with Metabolic Syndrome. Cell Metab. 2020 Jan 7;31(1):92-104.e5.
28. Johnson KO, Holliday A, Mistry N, Cunniffe A, Howard K, Stanger N, et al. An increase in fat-free mass is associated with higher appetite and energy intake in older adults: A randomised control trial. Nutrients. 2021 Jan 1;13(1):1–22.
29. Johnson KO, Holliday A, Mistry N, Cunniffe A, Howard K, Stanger N, et al. An increase in fat-free mass is associated with higher appetite and energy intake in older adults: A randomised control trial. Nutrients. 2021 Jan 1;13(1):1–22.
30. Moseley ODI, Roose B, Zelewski SJ, Kahmann S, Dey K, Stranks SD. Tunable Multiband Halide Perovskite Tandem Photodetectors with Switchable Response. ACS Photonics. 2022 Dec 21;9(12):3958–66.
31. Rojo-García AV, Vanmunster M, Pacolet A, Suhr F. Physical inactivity by tail suspension alters markers of metabolism, structure, and autophagy of the mouse heart. Physiol Rep. 2023 Jan 1;11(2).
32. Biere S, Kranz TM, Matura S, Petrova K, Streit F, Chiocchetti AG, et al. Risk Stratification for Bipolar Disorder Using Polygenic Risk Scores Among Young High- Risk Adults. Front Psychiatry. 2020 Oct 26;11.
33. Babaie J, asl YP, Naghipour B, Faridaalaee G. Cardiovascular Diseases in Natural Disasters; a Systematic Review. Arch Acad Emerg Med. 2021;9(1):1–16.
34. bjrcr.20190089.
35. Peng T, Lin Q, Li B, Luo A, Cong Q, Liu R. Stress superposition method and mechanical analysis properties of regular polygon membranes. Materials. 2022 Jan 1;15(1).