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A comprehensive review of intermittent fasting: Metabolic mechanisms, emerging health benefits and supportive role of phytonutrients

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Abstract

The intermittent fasting (IF) is widely discussed as a dietary method for optimizing metabolic functions. Intermittent fasting promotes the "metabolic switch" in favor of fat catabolism, which is accompanied by the activation of AMPK, inhibition of mTOR and stimulation of autophagy. All of these factors lead to improved insulin sensitivity in combination with anti-inflammatory and antioxidative effects. The clinical results indicate the effectiveness of using IF to achieve weight loss (from 1.4 to 2.5 kg), reduce fat mass (by about 0.72 kg) and decrease the level of HbA1c (up to 1.9%). The inclusion of nutraceuticals rich in phytonutrients (berberine, curcumin, resveratrol, EGCG, corosolic acid and ellagitannins) into the diet in addition to IF further increases the effectiveness of the intervention in terms of its impact on metabolic functions. The use of phytonutrients is effective for lowering blood glucose and lipids as well as inhibiting inflammation. Clinical data suggests that the proposed intervention can lead to a significant decrease in the level of triglycerides (up to 34.7%) and fasting blood glucose concentration (from 110.6 to 94.6 mg/dl), as well as a decrease in insulin resistance by 25%. Combining intermittent fasting and phytonutrient based nutraceuticals is a viable strategy for enhancing metabolic health. In future, the study should be extended to investigate long term effectiveness and synergy involved in such interventions.

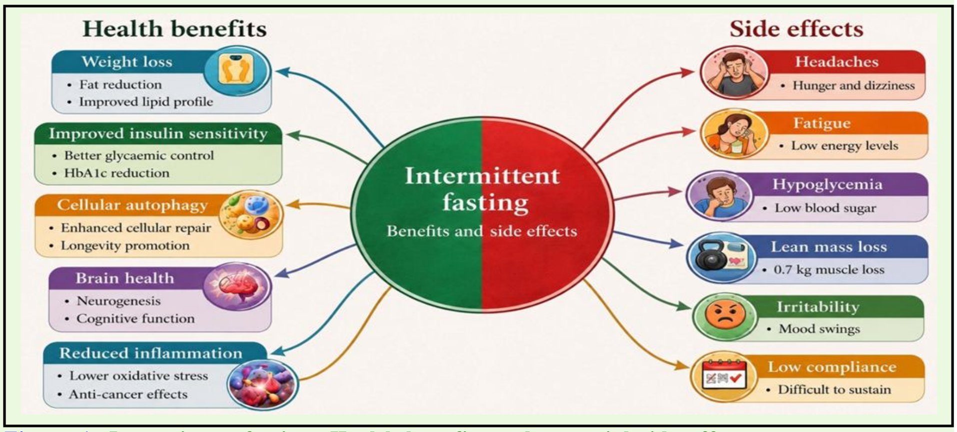

Figure 1: Intermittent fasting: Health benefits and potential side effects.

1. Introduction

Intermittent Fasting is considered to be an eating strategy whereby an individual will alternate between a period of fasting and feasting (Semnani-Azad *et al.*, 2025). The distinction between intermittent fasting and other diets can be based on the fact that while the other forms will focus on nutritional intake, intermittent fasting will emphasize consumption. The current popularity of the intermittent fasting method can be attributed to the benefits associated with weight control and metabolism regulation (Perez -Gerdel *et al.*, 2023).

There are various metabolic shifts that affect metabolism in the body to maintain energy homeostasis during fasting. First, glucose in the blood as well as glycogen in the body serve as sources of energy. Secondly, fats and ketones provide energy for brain and muscle cells (Wallerer *et al.*, 2025).

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There are different types of fasts that can be performed. First, the type of fasting that involves the use of time and period of fasting can be applied. This is the case whereby there is consumption of food for eight to ten hours and fasting for the rest of the fourteen to sixteen hours in a day. This is beneficial since it fits well into the biological clock and it also enhances fat metabolism and sensitivity to insulin (Jaschke, 2023). The second type of fasting is the alternate day fasting. In this case, there is feeding for one day and then there is total or partial fasting the following day (20-25% calorie intake) (Kalsekar *et al*., 2024; Anton *et al.,* 2018; Khalafi *et al*., 2024).

For example, one 5:2 diet involves a normal diet 5 times a week, and a 2 day per week fast in which the individual only consumes 500-600 calories. However, fasting for long-term periods (over 24 h) is a therapeutically applied treatment and is associated with autophagy and cellular function (Semnani-Azad *et al*., 2025). Both methods of fasting are proven to increase the metabolic function and energy expenditure (Gerdel *et al.,* 2023).

Along with intermittent fasting, phytochemical-rich nutraceuticals might prove effective for increasing the benefits of IF due to improved glucose and lipid metabolism. For instance, some examples of significant phytochemicals exhibiting hypoglycemic, hypolipidemic, anti-oxidative and anti-inflammatory characteristics are berberine extracted from *Berberis aristata*, corosolic acid and ellagitannins obtained from banaba (*Lagerstroemia speciosa*) and curcumin isolated from turmeric (*Curcuma longa*) (Stohs *et al.,* 2012). The action of these phytochemicals helps in improving insulin sensitivity and glucose transport, preventing gluconeogenesis and lowering oxidative stress and inflammation. In addition to this, there will be metabolic adaptations resulting from intermittent fasting like increased fat oxidation, reduction in insulin resistance and cardiovascular diseases risk factors. Therefore, both strategies together might yield positive results for people with impaired fasting glucose and metabolic syndrome (Cicero *et al.,* 2017).

2. Physiological mechanisms of intermittent fasting

Intervention through intermittent fasting leads to a number of changes in the body that allow it to sustain metabolic balance when food intake is low. An example of a quick response is the loss of glycogen stores in the liver that happens within 12-24 h after initiating fasting. Such action triggers metabolic switching, where the process of oxidizing fats replaces glucose as an energy source (Mattson *et al.,* 2017; De Cabo and Mattson *et al.,* 2020). It provides better metabolic flexibility and tissue adaptation.

2.1 Hormonal and cellular responses during fasting

Hormonal changes also play an important role during fasting. Reduced food intake lowers circulating insulin levels and increases glucagon secretion, thereby promoting lipolysis in adipose tissue and mobilization of stored triglycerides (Anton *et al.,* 2018; Varady *et al.,* 2021; Khalafi *et al*., 2025). As lipolysis increases, free fatty acids are released into the bloodstream and transported to the liver for β-oxidation and ketogenesis. Under normal feeding conditions, circulating ketone bodies remain low at about 0.1-0.2 mmol/l, but during prolonged fasting of 16-24 h, β-hydroxybutyrate levels may rise to 0.5-1.0 mmol/l, providing an efficient energy source for peripheral tissues and the central nervous system (Anton *et al.,* 2018). At the cellular level, intermittent fasting activates key nutrient sensing pathways that regulate metabolic homeostasis. A major regulator is AMP activated protein kinase (AMPK**)**, which is activated when cellular energy levels fall and the AMP/ATP ratio rises. AMPK activation promotes fatty acid oxidation, enhances glucose uptake and suppresses anabolic processes such as lipid and protein synthesis (Li *et al.*, 2023; Cho *et al.,* 2022). Studies further suggest that fasting induced AMPK activation improves mitochondrial efficiency and metabolic regulation in skeletal muscle and liver tissues (Regmi and Heilbronn *et al.,* 2020; Peters *et al.,* 2025).

2.2 mTOR inhibition, autophagy and cardiometabolic effects

Intermittent fasting also impacts the mammalian target of rapamycin (mTOR) pathway, which controls cell growth and protein production. During fasting, lower nutrient availability reduces mTOR activity. This shift directs cellular functions toward repair and maintenance instead of growth (Longo and Anderson *et al.,* 2024). This reduction is closely related to the activation of autophagy, a process that recycles damaged proteins and organelles. Studies have shown that fasting can nearly double autophagy related gene expression in metabolic tissues like the liver and skeletal muscle (De Cabo and Mattson *et al*., 2020; Madeo *et al.,* 2019). Besides these molecular changes, intermittent fasting leads to broader metabolic effects that may boost cardiometabolic health. Clinical studies indicate that fasting interventions lasting several weeks can lower fasting insulin levels by about 3-6 μIU/ml. They also significantly improve insulin sensitivity, including HOMA-IR values (Cienfuegos *et al.,* 2022; Varady *et al.,* 2021). Additionally, fasting has been linked to reductions in inflammatory markers, such as C-reactive protein and tumor necrosis factor-α. These markers may drop by around 10-20% after structured fasting programs (Khalafi *et al.,* 2025). These physiological responses, including glycogen depletion, metabolic switching increased lipolysis, activation of AMPK signalling, inhibition of mTOR pathways and stimulation of autophagy help create the metabolic and cellular changes seen during intermittent fasting. These processes are thought to improve metabolic flexibility, boost mitochondrial function, and support cellular repair. This suggests that intermittent fasting could play a valuable role in preventing metabolic diseases and promoting healthy aging (Longo and Anderson *et al.,* 2024; Varady *et al.,* 2021).

2.3 Clinical evidence supporting intermittent fasting

Intermittent fasting (IF) has become popular as a way to improve metabolic health, manage weight and prevent diseases. It differs from traditional calorie restriction by focusing on specific eating times (Varady *et al.,* 2021). This review gathers information from reputable umbrella reviews and meta analyses of randomized controlled trials (RCTs), to assess the effectiveness and safety of IF.

Protocols like modified alternate day fasting (MADF), 5:2 regimens and time restricted eating (TRE) result in moderate weight loss of 1.4-2.5 kg over 1-3 months for overweight or obese adults. They also lead to reductions in waist size (MD: -1.02 cm, 95% CI: -1.99 to -0.06), fat mass (MD: -0.72 kg, 95% CI: -1.32 to -0.12), fasting insulin levels (SMD: -0.21, 95% CI: -0.40 to -0.02), LDL cholesterol (SMD: -0.20), total cholesterol (SMD: -0.29) and triglycerides (SMD: -0.23). They also show a slight increase in HDL cholesterol (MD: 0.03 mmol/l) that is similar to continuous energy restriction (CER) (Wang *et al.,* 2024)

These benefits come from a shift in metabolism towards fatty acid oxidation, ketogenesis, improved insulin sensitivity (15-30% improvement), reduced inflammation and the activation of autophagy. This could help manage type 2 diabetes, support neurogenesis and lower cancer risk. However, about 20-30% of participants report early side effects such as headaches, fatigue, or low blood sugar (glucose drops of over 20 mg/dl in diabetics). There is also minor lean mass loss (-0.70 kg), and adherence drops to around 50% after 6 months without supervision (Cienfuegos *et al.,* 2022). IF can lead to 3-8% weight loss and some heart health benefits when aligned with circadian rhythms, but long-term RCTs (lasting more than 12 months) are needed to confirm its effectiveness in preventing cardiovascular events and its safety across different populations (Patikorn *et al.,* 2021).

3. Intermittent fasting responsive metabolic pathways

3.1 Metabolic organ responses to fasting stress

In order to consider the impact of intermittent fasting on the regulation of metabolism, differential expression of proteins was assessed in the liver, cerebral cortex and skeletal muscle (Horne, *et al.,* 2020). Among these, the liver showed the greatest changes in the expression of proteins suggesting that it is the dominant metabolic organ that responds to the physiological stress of fasting. The majority of proteins that changed in the liver are related to metabolism, while changes were less in the skeletal muscle and cerebral cortex (Browning *et al*., 2012).

3.2 Hepatic mitochondrial metabolism and antioxidant defense during fasting

Intermittent fasting leads to an increase in several proteins that can be related to mitochondrial energy metabolism in the liver. These proteins include the pyruvate dehydrogenase kinase isozyme 2, pyruvate dehydrogenase E1 beta subunit, and mitochondrial trans-2-enoyl-coenzyme A reductase, all of which participate in the metabolism of pyruvate and fatty acid oxidation. These processes will be essential to maintain the cellular energy balance during that fasting interval when the intake of nutrients is low (Luo *et al.,* 2022; Jiang *et al.,* 2023; Qian *et al.,* 2020). On top of that, other enzymes like long-chain acyl-coenzyme A dehydrogenase, 2,4-dienoyl-coenzyme A reductase 1 and 3-hydroxybutyrate dehydrogenase type 1 also facilitate in the expenses of lipids by being instrumental in the mobilization and oxidation of fatty acids that will serve as their alternative energy substrates during fasting and are said to be important in lipid catabolism (Makela *et al.,* 2019; Williams *et al.,* 2024).

The mechanisms of detoxification in the cells of the liver and antioxidants in fasting get activated through the increased production of proteins required for fasting. The activation of proteins such as cystathionine gamma-lyase, carboxylesterase 1C, glutathione S-transferase mu 2 and glutathione S-transferase 3 is necessary for keeping the hepatic cells protected from oxidation resulting from metabolic stress through the process of detoxification (Katsouda *et al.*, 2025; Gan *et al.,* 2023; Fafian *et al.,* 2020). Redox homeostasis of the cells experiencing stress as a result of nutrient deficiency gets facilitated by proteins such as glutathione peroxidase 3, ferredoxin reductase and aldo-keto reductase family 1 member B1 (Wu *et al*., 2023; Yu *et al.,* 2024).

3.3 Regulation of hepatic energy metabolism

The mechanism behind the effects of intermittent fasting on lipid transport and phospholipid synthesis is due to the control of certain proteins that regulate lipid homeostasis and cell membrane integrity, such as fatty acid-binding protein 5, cytidine monophosphate phosphate cytidylyltransferase 1 alpha and lipin 2 (Haider *et al.,* 2018; Zhang *et al.,* 2019). In addition, the regulation of glycosphingolipids and carbohydrate metabolism can be attributed to hexosaminidase subunit alpha, di-N-acetylchitobiase and beta-glucuronidase, emphasizing the importance of the liver in glucose regulation and glycoconjugate metabolism (Montgomery *et al.,* 2023; Bramwell *et al.,* 2015).

Intermittent fasting reduces the action of hepatic enzymes responsible for energy production and biosynthesis. Some enzymes related to the metabolism of xenobiotics and bile acid biosynthesis, such as CYP2E1, CYP3A13 and CYP7B1 have their levels lowered by intermittent fasting. The lower activity of HMG-CoA synthase 1 and farnesyl-diphosphate farnesyltransferase 1 is indicative of reduced biosynthesis of fatty acids and cholesterol (Dong *et al.*, 2024). Low levels of phosphofructokinase signify that less glycolysis is occurring due to intermittent fasting (Meng *et al*., 2024; Yuan *et al*., 2024).

Table 1: Clinical studies evaluating the effects of fasting protocols in cancer patients

Cancer type	Number of participants	Fasting protocol	Outcome	References
Astrocytoma (G2-4)	25	2 fasting days/week + modified Atkins diet	Well tolerated; high ketone levels	Schreck *et al.,* 2018
HER2-negative breast cancer	131	3-day fasting mimicking diet with chemotherapy	Similar toxicity; improved patho-logical response	De Groot *et al.,* 2020
Gynecological cancers	30	96 h fasting during chemotherapy	High ketones, low IGF-1, fewer side effects	Zorn *et al.,* 2020
Breast and ovarian cancer	34	Short term fasting during chemo therapy	Better well-being; reduced fatigue	Bauersfeld *et al.,* 2018
Early breast cancer	2413	Overnight fasting duration asses-sed	<13 h fasting linked with higher recurrence	Marinac *et al.,* 2016
Breast, ovarian and uterine cancers	20	24-72 h fasting before chemo-therapy	Safe; low neutropenia and DNA damage	Dorff *et al*., (2016)

4. Intermittent fasting in cancer prevention

Intermittent fasting helps in slowing cancer growth by reducing insulin and IGF-1 levels, leading to inhibition of PI3K-AKT-mTOR signalling and induction of autophagy (Tekar *et al.,* 2023; Al-Bari *et al.,* 2021). Some major autophagy markers include ATG5, ATG7, Beclin-1, LC3-II, LAMP-2 and Rab-7, which participate in autophagosome biogenesis and lysosome-mediated degradation. Mitophagy through the PINK1/Parkin mechanism facilitates the elimination of defective mitochondria and decreases ROS generation and DNA damage (Al-Bari *et al.,* 2021). Higher expression of Beclin-1 resulted in a greater 5 year survival rate in stage III colon cancer (Alshammari *et al.,* 2023).

5. Intermittent fasting for type II diabetes

5.1 Effects of intermittent fasting on glycemic and lipid parameters

The results of meta-analysis studies on people with dysfunctional glucose and lipids metabolism revealed that intermittent fasting had beneficial effects on clinical parameters, such as lowering fasting blood glucose levels by 0.15 mmol/l, HbA1c by 0.08, insulin by 13.25 µIU, and HOMA-IR by 0.31(Jamshed *et al.,* 2020). There were substantial physical benefits as well, which include a reduction in BMI by 0.8 kg/m², body weight by 1.87 kg and waist circumference by 2.08 cm (Yuan X *et al.,* 2022). The improvement in lipid markers was demonstrated by the reduction in total cholesterol by 0.32 mmol/l, LDL cholesterol by 0.22 mmol/l and triglyceride levels (0.04 mmol/l) (Shyamala *et al.,* 2025).

In an experiment lasting 3 months, the superiority of IF + CR was proven for managing type 2 diabetes compared to CR alone, resulting in significantly higher reductions in HbA1c levels (-0.50 vs. -0.20; $p = 0.002$), weight and body fat with equivalent results in improving insulin resistance; medications were reduced by 16% and 13%, respectively (p=0.308) (Fattah *et al.,* 2026). After 16 weeks, the highest HbA1c level reduction (-1.9%) was seen in the 5:2 diet group compared to metformin (-1.6%) and empagliflozin (-1.5%); 88.9% reached HbA1c <7% (Guo *et al.,* 2024; Ha, S *et al.,* 2020).

5.2 Long term clinical benefits of intermittent fasting

Both intermittent fasting and calorie restriction resulted in weight loss after one year (8% ± 2% vs. 6% ± 1%; p<0.0001) with equal decrease in fat mass and BMI (p<0.05). However, in terms of fasting insulin and insulin resistance, the results for IF group were significantly better (52% ± 9% and 53% ± 9%, respectively), compared to CR (14% ± 9% and 17% ± 11%) (Gabel *et al.,* 2019). IF demonstrated better results in verbal memory, resting heart rate, and blood pressure, in addition to lower body weight, fasting glucose, insulin and leptin levels with increased adiponectin in type 2 diabetics (Sutton *et al.,* 2018).

6. Intermittent fasting in neurogenesis

6.1 Hippocampal neurogenesis and neuroplasticity

Intermittent fasting for three months with duration 12 h, 16 h and 24 h per day on alternating days led to a significant increase in the formation of neurons in the hippocampus by raising NeuN, Nestin, PSD95, Notch1, NICD1, HES5, BDNF and p-CREB (p<0.0.05-0.001) with 16 h fasting showing maximal effects (Baik *et al.,* 2020). IL-6, which is produced through fasting and exercise, enhances the sensitivity of insulin and neuroplasticity of hippocampus. IGF-1 and FGF-2 are produced by neurons and astrocytes; both increase resistance to stress. Fasting decreases the level of IGF-1 in liver, while exercise elevates its concentration in circulation (Rahmani *et al.,* 2019).

6.2 Neuroprotective anti-inflammatory mechanisms

IF produces its neuro protective effects by suppressing neuro inflammation. IF acts by inhibiting the expression of genes responsible for the production of pro-inflammatory cytokines (such as TNF-α, IL-1, IL-6), chemokines (CCL2/MCP-1, CXCL2/MIP-2) and adhesion molecules *via* down regulation of the activation of the NF-êBsignaling pathway. The mechanism of this action occurs due to the action of SIRT1, which deacetylates p65 and thus inhibits the transcriptional activity of the molecule (Rahmani *et al.,* 2019). Intermittent fasting also decreases age-associated inflammation via suppression of NF-κB and MAPK pathways as well as oxidative stress leading to the prevention of neurodegenerative disorders such as parkinson's disease (Yu *et al.,* 2024).

7. Intermittent fasting in circadian rhythm

IF has considerable effects on the circadian rhythm, which is a natural 24 h biological clock system regulated by the SCN. While light acts as the primary zeitgeber to help coordinate the central clock system, feeding and fasting cycles act as the most important signal to ensure coordination between the peripheral clock system within different organs like the liver, stomach and adipose tissue (Yin *et al.,* 2022). The process of IF involves limiting the timing of food intake, which helps improve the coordination of the internal daily rhythm and enhances coordination between the central and peripheral clock systems (Bohlman *et al.,* 2024).

Fasting induces a shift in metabolism from glucose utilization to fat burning and ketone production, stimulating cell repair processes. Fasting modulates clock genes like CLOCK, BMAL1, PER and CRY, leading to increased insulin sensitivity, inflammation reduction and proper metabolic rhythm (Gu *et al.,* 2022). Proper timing of fasting in conjunction with day time eating ensures proper alignment with sleep wake rhythm, while misaligned or night time eating disturbs coordination between the SCN and other peripheral clocks (Petridi *et al.,* 2024).

The effects of early time restricted feeding have also been observed to be more beneficial than late time restricted feeding. For example, one study that lasted five weeks found that men with prediabetes had improved insulin sensitivity, lower blood pressure and enhanced glucose metabolism despite no changes in body weight (Peterson *et al.,* 2018; Eric Ravussin *et al.,* 2019).

8. Phytonutrients and bioactive foods supporting intermittent fasting

In a double blind randomized controlled trial with 40 subjects diagnosed with impaired fasting glucose, the 8 week supplementation with a nutraceutical formulation including berberine, corosolic acid, ellagitannins, curcumin, alpha-lipoic acid, chromium picolinate and folic acid caused significant changes in metabolicmarkers. In particular, the concentration of triglycerides was significantly reduced by 34.7%, going down from 186.4 ± 45.7 mg/dl to 121.8 ± 53.5 mg/dl, whereas the level of HDL cholesterol was increased by 13.7%, rising up from

46.7 ± 5.1 mg/dl to 53.1 ± 5.4 mg/dl. Furthermore, the fasting plasma glucose was considerably lower after treatment, at 110.6 ± 3.6 mg/dl versus 94.6 ± 3.9 mg/dl. The fasting insulin also demonstrated a noticeable decrease from 19.4 ± 4.1 µIU/ml to 16.8 ± 2.3 µIU/ml. Finally, the HOMA-IR index significantly dropped by 5.20 ± 0.84 to 3.92 ± 1.13, corresponding to a 25% reduction in insulin resistance, with statistically significant differences compared to placebo ($p<0.05$) (Cicero *et al.,* 2017). Phytonutrients such as resveratrol, EGCG, catechins and oleuropein help achieve these benefits through their ability to counter oxidative stress and down regulate the inflammatory cascade including NF-κB pathway (Figure 2). Furthermore, IF protocols can help reduce calorie intake spontaneously by approximately 37% in addition to body mass, visceral fat, and lipids (Cacciabaudo *et al.,* 2025).

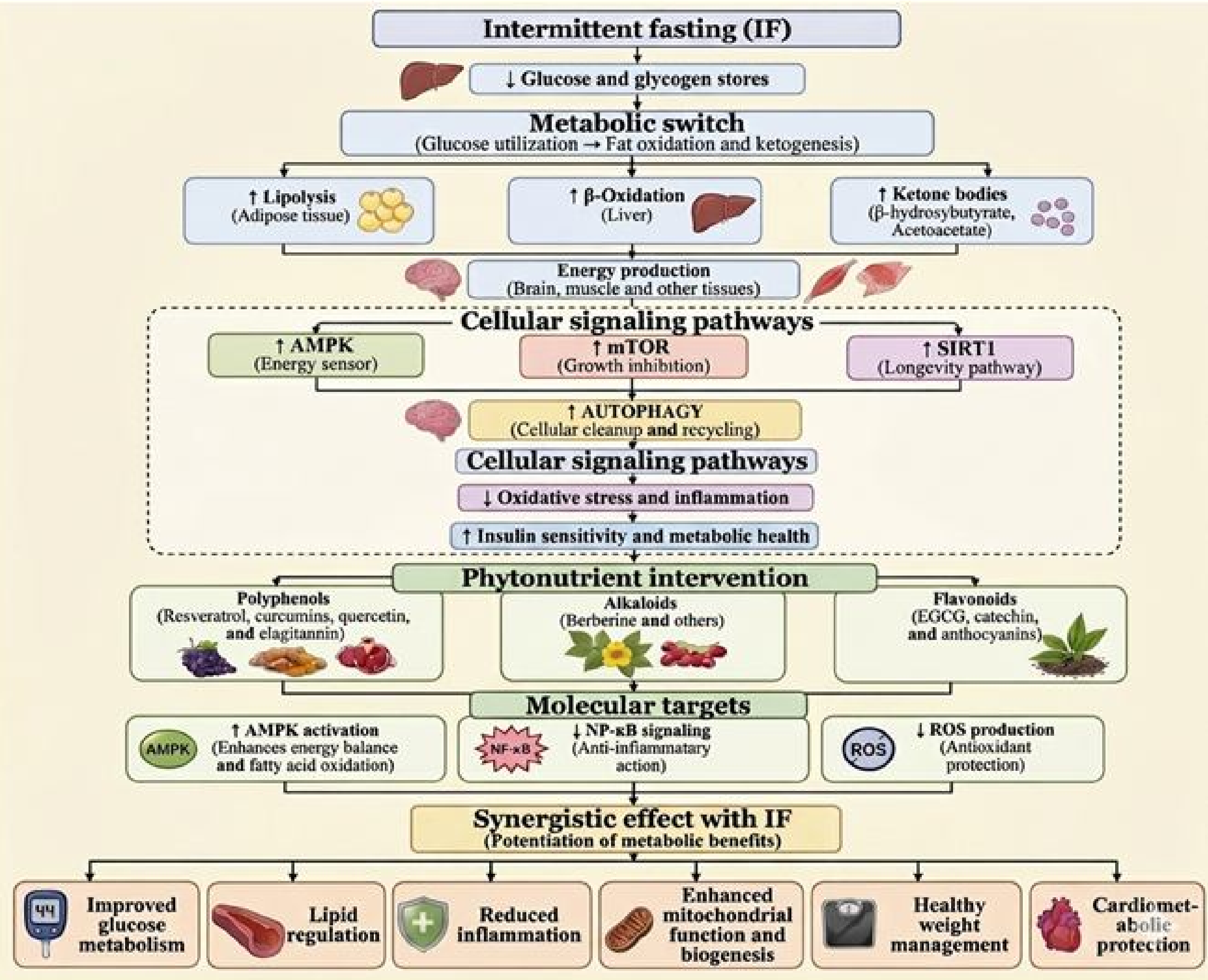

Figure 2: Cellular signalling pathways in intermittent fasting and the modulatory effects of phytonutrients.

9. Complications in intermittent fasting

In this regard, intermittent fasting can be considered one of the most widespread methods for weight loss and improving overall well being because of some new findings in science. In this case, the aim of conducting such a scientific investigation was to study the efficiency of intermittent fasting and identify any side effects associated with its usage (Jaschke, 2023). Moreover, the impact of intermittent fasting on the quality of people's lives was investigated as well. Consequently, it should be stated that the number of males was somewhat larger than the number of females. However, it does not correspond to other existing scientific papers, which revealed that more women use IF compared to men. Besides, the age of most subjects varied between 18 and 35 years old. Taking into account the relatively high level of BMI among the population under consideration, it can be suggested that weight loss was the reason why they started using this dieting method. Furthermore, most individuals used IF for less than three months (Alper *et al.,* 2021). Moreover, it should be noted that many of those people who began using intermittent fasting were active in sport. It can be stated that the majority of participants succeeded in reducing their weight, which was between 1 kg to 10 kg, whereas there were very few participants who gained additional weight. This is due to improper eating habits (Alhussain *et al.,* 2021).

There were several negative consequences of IF for patients, especially when they started this type of therapy. One of the most common was headaches, but other problems also appeared like dizziness, frequent urination, mood changes, and fatigue due to hypoglycemia during long fasting periods. In any case, most of them were mild to moderate (Ranjbar *et al.,* 2024). On the other hand, there were many patients who were quite satisfied with IF, but a few individuals were unhappy about it since their expectations were not met or their lifestyle did not fit well with this regimen. However, it should be mentioned that this research article is not without biases (Cui *et al*., 2025). One of the possible biases that can exist within this study is the selection of the participants *via* social media websites and the use of self reporting data. The biggest threat to the implementation of IF can be considered as a risk of developing hypoglycemia among patients who need to use insulin or antidiabetic. Other possible negative consequences of IF can include dizziness, fatigue, dehydration and poor adherence (Khalfallah *et al.,* 2023).

A correct time frame for meals in accordance with the circadian clock plays a key role in maintaining cardiometabolic health. Deviations from regularity, such as skipping breakfast andlatenight meals, predispose a person to an increased risk of cardiovascular disease and type 2 diabetes, whereas the regular intake of breakfast helps maintain metabolic homeostasis. Genomic changes in circadian genes, *e.g.,* CLOCK, have an impact on the way in which one reacts to fasting by disrupting glucose and lipid metabolism (Zhang *et al.,* 2021). The delay in timing of meals is associated with an increase in cardiovascular risk regardless of the body mass index (BMI) of the person (Cienfuegos *et al.,* 2022).

10. Conclusion

The intermittent fasting regimen has been shown to be quite effective in promoting the health of obese or overweight patients through the enhancement of their metabolic status. This dietary pattern has been found to help lower body mass index by 0.4-1.2 kg/m², waist circumference by 1.02 cm, fat mass by 0.72 kg and improve the status of systolic blood pressure. The diet has also proved effective in promoting the health of the body's lipids and metabolism by boosting the body's HDL cholesterol by 0.03 mmol/l and lowering the levels of fasting insulin, LDL cholesterol and triglycerides. Nevertheless, the diet may pose challenges such as lean mass loss (-0.70 kg) in the initial stages, risk of hypoglycemia in diabetic patients and low compliance rate when left unsupervised.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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