European Journal of Clinical Medicine
Vol 5 | Issue 5 | September 2024
ISSN 2736-5476

REVIEW

Intermittent Fasting on Cancer: An Update

Amália Cinthia Meneses do Rêgo [1,2] and Irami Araújo-Filho [1,23*]

ABSTRACT

Intermittent fasting (IF) has garnered considerable interest as a dietary intervention with potential therapeutic benefits for various medical conditions, particularly cancer. This review provides a comprehensive update on the effects of IF on cancer, emphasizing its impact on metabolic, hormonal, and cellular mechanisms. IF has been shown to improve glycemic control and reduce liver enzyme levels in patients with non-alcoholic fatty liver disease (NAFLD), suggesting a reduction in liver cancer risk. It can significantly reduce tumor growth and enhance apoptosis in breast cancer by lowering insulin-like growth factor 1 (IGF-1) levels. In patients with polycystic ovary syndrome (PCOS), IF offers superior metabolic and hormonal regulation, potentially lowering cancer risk. IF mitigates chemotherapy-related toxicities, thereby improving patient quality of life. It modulates metabolic pathways, reduces inflammation, and enhances drug delivery in cancer therapy. Personalized dietary strategies, including IF and ketogenic diets, are crucial in cancer care. IF also benefits liver conditions by reducing inflammation and fibrosis, preventing the progression to hepatocellular carcinoma. In obesity-induced triple-negative breast cancer, IF disrupts critical processes involved in cancer progression. In addition, aligning IF with circadian rhythms has shown promise in treating lung cancer. Patient perspectives reveal that IF is feasible and acceptable, improving treatment adherence and quality of life. Overall, IF represents a multifaceted approach to cancer prevention and therapy. This review advocates for further research to establish standardized guidelines for implementing IF in oncology, aiming to develop more effective and holistic cancer treatment strategies.

Keywords: Clinical oncology, integrative oncology, intermittent fasting, neoplasms.

Submitted: August 05, 2024

Published: September 30, 2024

10.24018/ejclinicmed.2024.5.5.345

[1] Institute of Teaching, Research, and Innovation, Liga Contra o Câncer, Brazil.
[2] Postgraduate Program in Biotechnology, Potiguar University (UnP), Brazil.
[3] Department of Surgery, Potiguar University, Brazil.

Corresponding Author:
e-mail: irami.filho@uol.com.br

1. Introduction

Intermittent fasting (IF) has emerged as a promising dietary approach with potential therapeutic benefits across various medical conditions, including cancer. IF involves alternating periods of eating and fasting, which can range from several hours to days, depending on the specific regimen [1]–[3].

This dietary pattern has gained considerable attention recently due to its ability to induce metabolic and cellular changes that may contribute to improved health outcomes. Cancer remains a leading cause of morbidity and mortality worldwide, necessitating continuous exploration of novel therapeutic strategies [2]–[4].

Traditional cancer treatments, such as chemotherapy, radiation, and surgery, often come with significant side effects and varying degrees of efficacy. There is a growing interest in adjunctive therapies that can enhance the effectiveness of conventional treatments while minimizing adverse effects [5]–[7].

Dietary interventions like intermittent fasting are being investigated for their potential role in cancer prevention and treatment. Several preclinical and clinical studies have suggested that intermittent fasting may exert anticancer effects through various mechanisms. These include modulating metabolic pathways, reducing inflammation, and enhancing autophagy and apoptosis in cancer cells [6]–[8].

Anemoulis *et al*. provided a critical update on the effects of intermittent fasting in breast cancer, highlighting its potential to improve clinical outcomes. The study reviewed available data, concluding that intermittent fasting can significantly reduce tumor growth and progression. The authors noted that fasting reduces insulin-like growth factor 1 (IGF-1) levels associated with cancer cell proliferation. This reduction in IGF-1 can enhance the efficacy

of breast cancer treatments by making cancer cells more susceptible to apoptosis [1].

Gabel *et al*. discussed the application of intermittent fasting during cancer chemotherapy, providing a comprehensive analysis of its benefits. Found that fasting periods could mitigate treatment-related toxicities, such as fatigue and gastrointestinal symptoms, thereby improving patients' quality of life. The mechanisms proposed include enhanced autophagy and reduced oxidative stress, which protect normal cells from the harsh effects of chemotherapy while selectively targeting cancer cells [2].

Becker *et al*. demonstrated that intermittent fasting could prime the tumor microenvironment, enhancing the delivery and effectiveness of nanomedicine in hepatocellular carcinoma. Fasting improved vascular normalization and increased the permeability of tumor blood vessels, allowing for more efficient delivery of therapeutic agents. This finding underscores the potential of intermittent fasting to enhance the efficacy of advanced cancer treatments [3].

Recent researchers have expanded on the various biological mechanisms by which intermittent fasting may impact cancer progression. One primary mechanism is altering IGF-1 levels, which promote cell proliferation and inhibit apoptosis. Fasting has been shown to reduce circulating levels of IGF-1, thereby potentially reducing cancer cell growth. Intermittent fasting induces a state of ketosis, where the body shifts from glucose to ketone bodies as a primary energy source [4]–[6].

This metabolic switch can be detrimental to cancer cells, which rely heavily on glucose for rapid proliferation. Intermittent fasting also impacts the immune system, enhancing its ability to target and destroy cancer cells. Studies have demonstrated that fasting can increase the activity of natural killer (NK) cells and cytotoxic T lymphocytes, which play crucial roles in the immune response against tumors [7], [8]. Moreover, fasting has been observed to decrease the levels of proinflammatory cytokines and increase anti-inflammatory markers, creating a less favorable environment for cancer progression [9], [10].

Gallage *et al*. explored the effects of a 5:2 intermittent fasting regimen on non-alcoholic steatohepatitis (NASH) and hepatocellular carcinoma (HCC). The ameliorated liver inflammation and fibrosis while blunting cancer development by activating hepatic PPARα and PCK1 pathways. Intermittent fasting can modulate liver metabolism and reduce the risk of liver cancer development in patients with chronic liver disease [11].

Son *et al*. investigated the effects of intermittent fasting on obesity-induced triple-negative breast cancer. IF attenuated cancer progression by disrupting critical processes such as cell cycle progression, epithelial-mesenchymal transition, and proinflammatory signaling. These highlight the potential of intermittent fasting as a complementary therapeutic approach, particularly in aggressive and hard-to-treat cancers like triple-negative breast cancer [12].

Li Sucholeiki *et al*. examined the impact of intermittent fasting on toxicities, symptoms, and quality of life in patients undergoing active cancer treatment. The study reported positive outcomes, indicating that intermittent fasting has direct anticancer effects and supports better management of treatment-related side effects [13].

Patients reported reduced fatigue, improved gastrointestinal function, and enhanced well-being, suggesting that intermittent fasting could be integrated into standard cancer care protocols to improve patient outcomes [14]–[16].

James *et al*. conducted a scoping review about the impact of intermittent fasting and caloric restriction on aging-related outcomes in adults. Intermittent fasting could improve metabolic health by reducing insulin resistance, inflammation, and oxidative stress, which are relevant to cancer progression. These findings suggest that intermittent fasting could be a valuable strategy for cancer prevention in older adults by maintaining metabolic health and reducing cancer risk [17].

In addition, Redding *et al*. explored the patient's perspective on applying intermittent fasting in gynecologic cancer. The study highlighted the feasibility and acceptability of intermittent fasting among patients, noting improvements in treatment adherence and quality of life. Patients reported feeling more in control of their health and experiencing fewer side effects from cancer treatments, underscoring the importance of patient-centered approaches in cancer care [18].

Ferro *et al*. demonstrated that therapeutic fasting reduced chemotherapy side effects in cancer patients, finding that fasting significantly reduced the severity of chemotherapy-induced toxicities and improved patients' quality of life. Clifton *et al*. also observed the effect of intermittent fasting in preventing and treating cancer, concluding that IF can enhance the effectiveness of conventional cancer therapies and reduce the side effects of treatment [8], [19].

Stringer *et al*. examined the role of intermittent fasting in cancer survivorship, suggesting that IF can help survivors manage long-term health outcomes and improve their quality of life. Mishra *et al*. reviewed the effects of nutrition and dietary restrictions in cancer prevention, emphasizing the potential of intermittent fasting to lower cancer risk through metabolic regulation and reduced inflammation. Bauersfeld *et al*. explored the effects of short-term fasting on quality of life and tolerance to chemotherapy in breast and ovarian cancer patients, finding that fasting improved patients' tolerance to treatment and reduced adverse effects [10], [20], [21].

Antunes *et al*. discussed the connection between autophagy and intermittent fasting in cancer therapy, highlighting the potential of fasting to enhance autophagy and improve cancer treatment outcomes [22]. Vidoni *et al*. reviewed calorie restriction and intermittent fasting for cancer prevention and therapy, suggesting that these dietary interventions can inhibit cancer growth and improve treatment efficacy [23]. Contiero *et al*. found that fasting blood glucose levels were associated with long-term prognosis in non-metastatic breast cancer, indicating that metabolic regulation through fasting could improve cancer outcomes [24].

Overall, intermittent fasting represents a multifaceted cancer prevention and treatment approach, leveraging metabolic, immunological, and cellular mechanisms to inhibit cancer progression and enhance treatment efficacy.

The heterogeneity of cancer types and individual patient responses necessitates further research to establish standardized guidelines for implementing intermittent fasting in oncology [16]–[18].

This review aims to provide a comprehensive overview of the current evidence on the relationship between intermittent fasting and cancer, exploring its underlying mechanisms, clinical applications, and future research directions. By understanding the intricate interactions between diet and cancer biology, we can develop more effective and holistic strategies to combat this devastating disease.

2. Methods

The research strategy employed for this study was meticulously designed to encompass an exhaustive review of literature across several distinguished databases known for their extensive collection of medical and scientific peer-reviewed publications. The databases selected for this comprehensive search included PubMed, Scopus, Scielo, Embase, and Web of Science, each renowned for their vast repository of scholarly articles. Google Scholar was also a supplementary resource for accessing the so-called gray literature, which often contains significant studies and reports unavailable in conventional academic journals. The focal point of this research was the intersection of intermittent fasting and its effects on clinical oncology, guiding the formulation of search parameters. A carefully curated set of keywords was deployed to optimize the search, comprising terms such as *intermittent fasting*, *clinical oncology*, *neoplasms*, integrative oncology, and *metabolism*. This strategic combination of keywords was instrumental in filtering the literature to include studies directly pertinent to the research objectives. To ensure a broad yet relevant data collection, the inclusion criteria were designed to be comprehensive, welcoming a variety of study designs, including systematic reviews, case-control studies, cross-sectional analyses, case series, and scholarly reviews. Such diversity in study types aimed to capture a spectrum of evidence and viewpoints regarding the nexus between intermittent fasting and cancer treatment and prevention. The literature review's evaluation and selection process was executed strictly with methodological rigor. This involved a dual-review system, where pairs of reviewers independently and blindly evaluated each study's title and abstract for relevance and conformity to the predefined criteria. Discrepancies between reviewers were resolved through consultation with a third independent reviewer to reach a consensus, ensuring the selection was based on solid and unbiased judgment. This detailed and systematic approach to research methodology underpins the reliability and validity of the findings presented and ensures that the conclusions drawn from this study are grounded in a comprehensive and critically evaluated body of scientific evidence related to intermittent fasting and oncology.

3. Results and Discussion

Intermittent fasting (IF) has emerged as a significant dietary intervention with promising therapeutic benefits across a range of medical conditions, including cancer. This discussion integrates findings from numerous pivotal studies, comprehensively analyzing IF's multifaceted effects on metabolic, hormonal, and cellular pathways and emphasizing its potential role in oncology [14]–[16]. The evidence underscores IF's promise as a substantial adjunct in enhancing treatment outcomes and improving patients' quality of life (Table 1) [9]–[12].

Saleh *et al*. assess the impact of IF regimens on glycemic, hepatic, anthropometric, and clinical markers in patients with non-alcoholic fatty liver disease (NAFLD). Their findings revealed significant glycemic control improvements and liver enzyme level reductions, indicating enhanced liver function. These results suggest that IF can address key risk factors associated with liver cancer by improving metabolic health in NAFLD patients. The reduction in insulin resistance and inflammation is a critical factor in preventing the progression of NAFLD to hepatocellular carcinoma [25].

Complementing these findings, Anemoulis *et al*. provided a critical update on the effects of IF in breast cancer, demonstrating its potential to improve clinical outcomes. Their systematic review concluded that IF can significantly reduce tumor growth and progression by lowering insulin-like growth factor 1 (IGF-1) levels, which are known to promote cancer cell proliferation. This reduction in IGF-1 enhances the susceptibility of cancer cells to apoptosis, thereby improving the efficacy of breast cancer treatments [1].

In a related context, Talebi *et al*. explored the effects of IF alone or combined with probiotic supplementation compared to a calorie-restricted diet on the metabolic and hormonal profile of patients with polycystic ovary syndrome (PCOS). Their study protocol for a randomized clinical trial proposed that IF could offer superior metabolic and hormonal regulation compared to standard calorie restriction. The anticipated outcomes include improved insulin sensitivity, reduced androgen levels, and better menstrual regularity, potentially lowering cancer risk in PCOS patients by addressing the underlying metabolic and hormonal imbalances [26].

Moreover, Gabel *et al*. discussed the application of IF during cancer chemotherapy and its benefits in mitigating treatment-related toxicities such as fatigue and gastrointestinal symptoms, thus improving patients' quality of life. The proposed mechanisms include enhanced autophagy and reduce oxidative stress, which protect normal cells from the harsh effects of chemotherapy while selectively targeting cancer cells. This finding underscores the dual role of IF in enhancing treatment efficacy and improving patient tolerance to chemotherapy [2].

Further expanding on these mechanisms, Psara *et al*. demonstrated the potential anticancer molecular mechanisms of IF, focusing on its ability to modulate metabolic pathways, reduce inflammation, and enhance autophagy and apoptosis in cancer cells. Their study emphasized that IF could inhibit cancer development and progression

by disrupting the energy supply to cancer cells, inducing oxidative stress, and triggering cell death pathways [27].

In another significant study, Becker *et al*. noted that IF could prime the tumor microenvironment, enhancing the delivery and effectiveness of nanomedicine in hepatocellular carcinoma. Their findings showed that fasting improved vascular normalization and increased the permeability of tumor blood vessels, allowing for more efficient delivery of therapeutic agents. This underscores the potential of IF to enhance the efficacy of advanced cancer treatments [3].

Küçük and Çiftçi investigated the role of IF and the ketogenic diet in cancer disease, comparing their efficacy to the Mediterranean diet. They concluded that while IF and the ketogenic diet showed promise in modulating cancer metabolism and growth, the Mediterranean diet's overall health benefits, including cancer prevention, were superior [28].

Additionally, Gallage *et al*. explored the effects of a 5:2 IF regimen on non-alcoholic steatohepatitis (NASH) and hepatocellular carcinoma (HCC). Fasting ameliorated liver inflammation and fibrosis while blunting cancer development by activating hepatic PPARα and PCK1 pathways. These IF's dual benefits in treating liver conditions and preventing liver cancer [11].

Son *et al*. investigating the effects of IF on obesity-induced triple-negative breast cancer. IF attenuated cancer progression by disrupting critical processes such as cell cycle progression, epithelial-mesenchymal transition, and proinflammatory signaling. These results emphasize IF's potential as a complementary therapeutic approach, particularly in aggressive and hard-to-treat cancers like triple-negative breast cancer [29].

Xiong *et al*. examined the impact of IF on type 1 diabetes-induced cognitive dysfunction. Their findings indicated that IF improved metabolic disorders in the frontal cortex, suggesting potential neuroprotective effects. While not directly related to cancer, these results imply that IF can enhance overall brain health, potentially reducing the risk of neuro-oncological conditions [30].

Shi *et al*. explored the effects of six-hour time-restricted feeding on lung cancer progression and circadian metabolism. IF inhibited lung cancer growth and reshaped circadian metabolism, emphasizing the importance of aligning dietary interventions with circadian rhythms to optimize cancer treatment outcomes [31].

Wang *et al*. analyzed the association between breakfast skipping and all-cause, cardiovascular, and cancer mortality. Their study concluded that breakfast skipping was associated with increased mortality risk, including cancer mortality. The results suggested that meal timing and regularity are crucial factors in cancer prevention, complementing IF's benefits [32].

Further supporting these findings, de Groot *et al*. evaluated the effects of short-term fasting on cancer treatment, finding that fasting before chemotherapy significantly reduced treatment-related side effects and improved the overall therapeutic index. Fasting enhances the body's resilience to the toxic effects of chemotherapy while selectively targeting cancer cells [33].

Tiwari *et al*. provided a comprehensive narrative review on the effect of fasting on cancer, highlighting the diverse mechanisms through which fasting can influence cancer progression and treatment outcomes. The potential of fasting is to modulate key metabolic and cellular pathways, thereby enhancing the effectiveness of cancer therapies [7].

TABLE I: Intermittent Fasting and Cancer

Author	Study	Results
Anemoulis *et al*. [1]	Systematic review	IF reduced tumor growth and progression in breast cancer by lowering IGF-1 levels, enhancing apoptosis.
Gabel *et al*. [2]	Comprehensive analysis	IF mitigated chemotherapy-related toxicities like fatigue and gastrointestinal symptoms, improving quality of life.
Becker *et al*. [3]	Experimental study	IF improved vascular normalization and increased permeability of tumor blood vessels, enhancing nanomedicine delivery in hepatocellular carcinoma.
Clifton *et al*. [8]	Review	IF enhanced the effectiveness of conventional cancer therapies and reduced side effects.
Gallage *et al*. [11]	Experimental study	IF ameliorated liver inflammation and fibrosis and reduced liver cancer development by activating hepatic PPARα and PCK1 pathways.
Son *et al*. [12]	Preclinical study	IF disrupted cell cycle progression, epithelial-mesenchymal transition, and proinflammatory signaling in triple-negative breast cancer.
James *et al*. [17]	Scoping review	IF improved metabolic health markers like insulin sensitivity, inflammation, and oxidative stress, relevant to cancer prevention.
Redding *et al*. [18]	Patient perspective study	Patients found IF feasible and acceptable, reporting improved treatment adherence and quality of life in gynecologic cancer.
Ferro *et al*. [19]	Systematic review and meta-analysis	IF reduced chemotherapy-induced toxicities and improved quality of life in cancer patients.
Stringer *et al*. [20]	Review	IF can help cancer survivors manage long-term health outcomes and improve quality of life.
Xiong *et al*. [30]	Preclinical study	IF improved metabolic disorders in the frontal cortex, suggesting neuroprotective effects, which may indirectly reduce neuro-oncological risks.
Shi *et al*. [31]	Preclinical study	Six-hour time-restricted feeding inhibited lung cancer growth and reshaped circadian metabolism.
Wang *et al*. [32]	Systematic review and meta-analysis	Breakfast skipping associated with increased mortality risk, including cancer mortality, highlighting the importance of meal timing and regularity.

Kikomeko *et al*. explored the combination of short-term fasting and fasting-mimicking diets with chemotherapy, finding that these dietary interventions can synergize with conventional treatments to improve therapeutic outcomes. Fasting reduces the side effects of chemotherapy and enhances its efficacy by sensitizing cancer cells to therapy [34].

de Gruil *et al*. examined the synergistic effects of short-term fasting with solid cancer therapy, demonstrating that fasting boosts antitumor immunity by enhancing the activity of immune cells, such as natural killer cells and cytotoxic T lymphocytes. This shows the potential of fasting to improve the body's natural defence mechanisms against cancer [35].

Finally, Thompson *et al*. conducted an integrative review on the impact of fasting on cancer patients, concluding that fasting interventions can significantly improve quality of life, reduce treatment-related toxicities, and enhance overall treatment outcomes. The integration of fasting into standard cancer care protocols to optimize patient well-being and therapeutic efficacy [36].

Overall, intermittent fasting represents a multifaceted cancer prevention and treatment approach, leveraging metabolic, immunological, and cellular mechanisms to inhibit cancer progression and enhance treatment efficacy. The heterogeneity of cancer types and individual patient responses necessitates further research to establish standardized guidelines for implementing intermittent fasting in oncology [8]–[10].

This review provides a comprehensive overview of the current evidence on the relationship between intermittent fasting and cancer, exploring its underlying mechanisms, clinical applications, and future research directions. By understanding the intricate interactions between diet and cancer biology, we can develop more effective and holistic strategies to combat this devastating disease.

4. Conclusion

Intermittent fasting represents a multifaceted cancer prevention and treatment approach, leveraging metabolic, immunological, and cellular mechanisms to inhibit cancer progression and enhance treatment efficacy.

The heterogeneity of cancer types and individual patient responses necessitates further research to establish standardized guidelines for implementing intermittent fasting in oncology.

This review provides a comprehensive overview of the current evidence on the relationship between intermittent fasting and cancer, exploring its underlying mechanisms, clinical applications, and future research directions. By understanding the intricate interactions between diet and cancer biology, we can develop more effective and holistic strategies to combat this devastating disease.

Acknowledgment

Authors thank the Federal University of Rio Grande do Norte, Potiguar University, and Liga Contra o Cancer for supporting this study.

Conflict of Interest

Authors declare that there is no conflict of interest.

References

[1] Anemoulis M, Vlastos A, Kachtsidis V, Karras SN. Intermittent fasting in breast cancer: a systematic review and critical update of available studies. *Nutrients*. 2023 Jan 19;15(3):532. doi: 10.3390/nu15030532.

[2] Gabel K, Cares K, Varady K, Gadi V, Tussing-Humphreys L. Current evidence and directions for intermittent fasting during cancer chemotherapy. *Adv Nutr*. 2022 Mar;13(2):667–80. doi: 10.1093/advances/nmab132.

[3] Becker S, Momoh J, Biancacci I, Möckel D, Wang Q, May JN, *et al*. Intermittent fasting primes the tumor microenvironment and improves nanomedicine delivery in hepatocellular carcinoma. *Small*. 2023 Oct;19(43):e2208042. doi: 10.1002/smll.202208042.

[4] O'Flanagan CH, Smith LA, McDonell SB, Hursting SD. When less may be more: calorie restriction and response to cancer therapy. *BMC Med*. 2017 May 24;15(1):106. doi: 10.1186/s12916-017-0873-x.

[5] Vidoni C, Ferraresi A, Esposito A, Maheshwari C, Dhanasekaran DN, Mollace V, *et al.* Calorie restriction for cancer prevention and therapy: mechanisms, expectations, and efficacy. *J Cancer Prev*. 2021 Dec 30;26(4):224–36. doi: 10.15430/JCP.2021.26.4.224.

[6] Kalam F, James DL, Li YR, Coleman MF, Kiesel VA, Cespedes Feliciano EM, *et al.* Intermittent fasting interventions to leverage metabolic and circadian mechanisms for cancer treatment and supportive care outcomes. *J Natl Cancer Inst Monogr*. 2023 May 4;2023(61):84–103. doi: 10.1093/jncimonographs/lgad008.

[7] Tiwari S, Sapkota N, Han Z. Effect of fasting on cancer: a narrative review of scientific evidence. *Cancer Sci*. 2022 Oct;113(10):3291–3302. doi: 10.1111/cas.15492.

[8] Clifton KK, Ma CX, Fontana L, Peterson LL. Intermittent fasting in the prevention and treatment of cancer. *CA Cancer J Clin*. 2021 Nov;71(6):527–46. doi: 10.3322/caac.21694.

[9] Szypowska A, Regulska-Ilow B. Significance of low-carbohydrate diets and fasting in patients with cancer. *Rocz Panstw Zakl Hig*. 2019;70(4):325–36. doi: 10.32394/rpzh.2019.0083.

[10] Mishra A, Giuliani G, Longo VD. Nutrition and dietary restrictions in cancer prevention. *Biochim Biophys Acta Rev Cancer*. 2024 Jan;1879(1):189063. doi: 10.1016/j.bbcan.2023.189063.

[11] Gallage S, Ali A, Barragan Avila JE, Seymen N, Ramadori P, Joerke V, *et al.* A 5: 2 intermittent fasting regimen ameliorates NASH and fibrosis and blunts HCC development via hepatic PPARα and PCK1. *Cell Metab*. 2024 Jun 4;36(6):1371−1393.e7. doi: 10.1016/j.cmet.2024.04.015.

[12] Son DS, Done KA, Son J, Izban MG, Virgous C, Lee ES, *et al.* Intermittent fasting attenuates obesity-induced triple-negative breast cancer progression by disrupting cell cycle, epithelial-mesenchymal transition, immune contexture, and proinflammatory signature. *Nutrients*. 2024 Jul 1;16(13):2101. doi: 10.3390/nu16132101.

[13] Li Sucholeiki R, Propst CL, Hong DS, George GC. Intermittent fasting and its impact on toxicities, symptoms and quality of life in patients on active cancer treatment. *Cancer Treat Rev*. 2024 May;126:102725. doi: 10.1016/j.ctrv.2024.102725.

[14] Thompson S, Madsen LT, Bazzell A. Impact of fasting on patients with cancer: an integrative review. *J Adv Pract Oncol*. 2023 Nov;14(7):608–19. doi: 10.6004/jadpro.2023.14.7.5.

[15] Deligiorgi MV, Liapi C, Trafalis DT. How far are we from prescribing fasting as anticancer medicine? *Int J Mol Sci*. 2020 Dec 1;21(23):9175. doi: 10.3390/ijms21239175.

[16] Zhao X, Yang J, Huang R, Guo M, Zhou Y, Xu L. The role and its mechanism of intermittent fasting in tumors: friend or foe? *Cancer Biol Med*. 2021 Feb 15;18(1):63–73. doi: 10.20892/j.issn.2095-3941.2020.0250.

[17] James DL, Hawley NA, Mohr AE, Hermer J, Ofori E, Yu F, *et al.* Impact of intermittent fasting and/or Caloric restriction on aging-related outcomes in adults: a scoping review of randomized controlled trials. *Nutrients*. 2024 Jan 20;16(2):316. doi: 10.3390/nu16020316.

[18] Redding A, Santarossa S, Murphy D, Udumula MP, Munkarah A, Hijaz M, *et al.* A patient perspective on applying intermittent fasting in gynecologic cancer. *BMC Res Notes*. 2023 Aug 29;16(1):190. doi: 10.1186/s13104-023-06453-5.

[19] Ferro Y, Maurotti S, Tarsitano MG, Lodari O, Pujia R, Mazza E, *et al.* Therapeutic fasting in reducing chemotherapy side effects in

cancer patients: a systematic review and meta-analysis. *Nutrients*. 2023 Jun 8;15(12):2666. doi: 10.3390/nu15122666.
[20] Stringer E, Lum JJ, Macpherson N. Intermittent fasting in cancer: a role in survivorship? *Curr Nutr Rep*. 2022 Sep;11(3):500–7. doi: 10.1007/s13668-022-00425-0.
[21] Bauersfeld SP, Kessler CS, Wischnewsky M, Jaensch A, Steckhan N, Stange R, *et al.* The effects of short-term fasting on quality of life and tolerance to chemotherapy in patients with breast and ovarian cancer: a randomized cross-over pilot study. *BMC Cancer*. 2018 Apr 27;18(1):476. doi: 10.1186/s12885-018-4353-2.
[22] Antunes F, Erustes AG, Costa AJ, Nascimento AC, Bincoletto C, Ureshino RP, *et al.* Autophagy and intermittent fasting: the connection for cancer therapy? *Clinics (Sao Paulo)*. 2018 Dec 10;73(suppl 1):e814s. doi: 10.6061/clinics/2018/e814s.
[23] Vidoni C, Ferraresi A, Esposito A, Maheshwari C, Dhanasekaran DN, Mollace V, *et al.* Calorie restriction for cancer prevention and therapy: mechanisms, expectations, and efficacy. *J Cancer Prev*. 2021 Dec 30;26(4):224–36. doi: 10.15430/JCP.2021.26.4.224.
[24] Contiero P, Berrino F, Tagliabue G, Mastroianni A, Di Mauro MG, Fabiano S, *et al.* Fasting blood glucose and long-term prognosis of non-metastatic breast cancer: a cohort study. *Breast Cancer Res Treat*. 2013 Apr;138(3):951–9. doi: 10.1007/s10549-013-2519-9.
[25] Saleh SAK, Santos HO, Găman MA, Cerqueira HS, Zaher EA, Alromaih WR, *et al.* Effects of intermittent fasting regimens on glycemic, hepatic, anthropometric, and clinical markers in patients with non-alcoholic fatty liver disease: systematic review and meta-analysis of randomized controlled trials. *Clin Nutr ESPEN*. 2024 Feb;59:70–80. doi: 10.1016/j.clnesp.2023.11.009.
[26] Talebi S, Shab-Bidar S, Mohammadi H, Moini A, Djafarian K. The effects of intermittent fasting diet alone or in combination with probiotic supplementation in comparison with calorie-restricted diet on metabolic and hormonal profile in patients with polycystic ovary syndrome: study protocol for a randomized clinical trial. *Trials*. 2023 Oct 25;24(1):690. doi: 10.1186/s13063-023-07691-5.
[27] Psara E, Poulios E, Papadopoulou SK, Tolia M, Vasios GK, Giaginis C. Intermittent fasting against cancer development and progression: highlighting potential anticancer molecular mechanisms. *Anticancer Agents Med Chem*. 2023;23(17):1889–909. doi: 10.2174/1871520623666230816090229.
[28] Küçük AN, Çiftçi S. The role of intermittent fasting and the ketogenic diet in cancer disease: can they replace the Mediterranean diet? *Eur J Cancer Prev*. 2023 Nov 1;32(6):533–43. doi: 10.1097/CEJ.0000000000000820.
[29] Son DS, Done KA, Son J, Izban MG, Virgous C, Lee ES, *et al.* Intermittent fasting attenuates obesity-induced triple-negative breast cancer progression by disrupting cell cycle, epithelial-mesenchymal transition, immune contexture, and proinflammatory signature. *Nutrients*. 2024 Jul 1;16(13):2101. doi: 10.3390/nu16132101.
[30] Xiong F, Jiang K, Wu Y, Lou C, Ding C, Zhang W, *et al.* Intermittent fasting alleviates type 1 diabetes-induced cognitive dysfunction by improving the frontal cortical metabolic disorder. *Biochim Biophys Acta Mol Basis Dis*. 2023 Oct;1869(7):166725. doi: 10.1016/j.bbadis.2023.166725.
[31] Shi D, Fang G, Chen Q, Li J, Ruan X, Lian X. Six-hour time-restricted feeding inhibits lung cancer progression and reshapes circadian metabolism. *BMC Med*. 2023 Nov 3;21(1):417. doi: 10.1186/s12916-023-03131-y.
[32] Wang Y, Li F, Li X, Wu J, Chen X, Su Y, *et al.* Breakfast skipping and risk of all-cause, cardiovascular and cancer mortality among adults: a systematic review and meta-analysis of prospective cohort studies. *Food Funct*. 2024 Jun 4;15(11):5703–13. doi: 10.1039/d3fo05705d.
[33] de Groot S, Pijl H, van der Hoeven JJM, Kroep JR. Effects of short-term fasting on cancer treatment. *J Exp Clin Cancer Res*. 2019 May 22;38(1):209. doi: 10.1186/s13046-019-1189-9.
[34] Kikomeko J, Schutte T, van Velzen MJM, Seefat R, van Laarhoven HWM. Short-term fasting and fasting mimicking diets combined with chemotherapy: a narrative review. *Ther Adv Med Oncol*. 2023 Mar 22;15:17588359231161418. doi: 10.1177/17588359231161418.
[35] de Gruil N, Pijl H, van der Burg SH, Kroep JR. Short-term fasting synergizes with solid cancer therapy by boosting anti-tumor immunity. *Cancers (Basel)*. 2022 Mar 9;14(6):1390. doi: 10.3390/cancers14061390.
[36] Thompson S, Madsen LT, Bazzell A. Impact of fasting on patients with cancer: an integrative review. *J Adv Pract Oncol*. 2023 Nov;14(7):608–19. doi: 10.6004/jadpro.2023.14.7.5.