The Role of Calorie Restriction in Cancer Prevention, Cancer Treatment, Longevity, and in Reducing Cellular Stress

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ABSTRACT

Cancer is one of the top main illnesses worldwide. The aging of the population and the widespread presence of risk factors including obesity, smoking, and/or bad eating habits are expected to contribute to its further rise. Chemotherapy, radiation therapy, and surgery continue to be the cornerstones of cancer treatment, despite the gradual replacement or supplementation of these methods by innovative treatments. The American Cancer Society suggests a high-calorie, high-protein diet for cancer patients undergoing chemotherapy. Furthermore, there are no established recommendations for the kind of diet that would significantly reduce cancer rates. However, calorie restriction (CR) and fasting, two common methods of reducing caloric consumption, show a broad variety of positive benefits that may prevent malignancies and boost the effectiveness of cancer treatments. Periodic fasting (PF), fasting-mimicking diets, and restricted food intake without first a decrease in calories have become popular as interventions with the potential to be widely used to prevent and treat cancer, while chronic CR provides both beneficial and detrimental effects and major compliance challenges. In this article, we discuss the impact that calorie restriction has in preventing cancer, aiding in cancer treatment, producing cellular protection and chemotherapy resistance in animal models and early human investigations.

Keywords: Calorie restriction, Cancer prevention, Intermittent fasting, Longevity.

1. Introduction

The effect that restricting one’s diet may have on one’s health is an area of study. The effects of dietary restrictions on health and disease prevention have been investigated and include calorie restriction, food exclusions, and changes to macronutrient intake [1]. Calorie restriction has been demonstrated to have positive benefits on lifespan extension and anti-aging mechanisms, notably in animal research [1].

Potential benefits for metabolic health from time-restricted feeding, fasting, low-carbohydrate diets, to various kinds of dietary restriction have shown promise for optimal metabolic health. Losing weight, increasing insulin sensitivity, decreasing inflammation, and improving lipid profiles are all linked to these dietary strategies. Dietary patterns that stress whole foods, fruits, vegetables, and lean meats, such as the Mediterranean and DASH diets, have been demonstrated to have positive impacts on cardiovascular health [1]. Lower blood pressure, healthier lipid profiles, and a decreased risk of cardiovascular disease have all been linked to these diets. Dietary restrictions, especially plant-based diets and diets rich in phytochemicals, have been linked to a reduced risk of cancer. Fiber, antioxidants, and other bioactive components in these diets have demonstrated an anti-cancer effect [1]. However, further research is needed to determine the precise processes and effective dietary methods for cancer prevention.

One of the most powerful and broadly acting dietary interventions for preventing or reversing weight gain and inhibiting cancer in experimental tumor models is calorie restriction (CR). Calorie restriction is a dietary regimen in which subjects, typically test animals, receive a reduced energy diet such as a 20% to 40% reduction in total energy intake relative to an unrestricted comparison group [19]. The beneficial effects of CR on metabolism and
chronic disease risk observed in rodent models may translate to humans, as shown by recent reports of a reduced risk of diabetes, neurological degeneration, and cancer in response to CR in rhesus monkeys and observations that CR decreases inflammatory and endocrine markers associated with increased breast cancer risk in women.

Additional data from observational epidemiologic research [9], [19] suggests that CR reduces mortality and cancer risk in humans. Okinawans in Japan, for instance, have always had lower mortality rates from cancer and other chronic illnesses than Okinawans on the Japanese mainland because they consume much less calories than residents of the major Japanese islands. Early-onset anorexia nervosa patients, and by extension those who have experienced periods of calorie restriction, had a lower chance of developing breast cancer [19]. Further supporting the idea that CR lowers cancer risk are surveillance data from communities subjected to varied degrees of calorie restriction during World War II. Overall, there is promising evidence that dietary restriction may improve health outcomes; however, further study is required to determine the full extent of these benefits and the safest and most effective ways to implement them.

Current research on the effects of calorie restriction on cancer prevention, therapy, and cellular defense are discussed. Our goal is to provide a comprehensive knowledge of the possible advantages and limits of calorie restriction in these settings by combining the data from epidemiological research, preclinical models, and clinical trials. Incorporating calorie restriction measures for cancer prevention, treatment, and cellular protection is a complex topic, and this review adds to the current information and help healthcare professionals, researchers, and people make educated choices.

2. Methods

Many sources are explored to investigate the effects of CR on cancer prevention, treatment, and cellular effects. The role of CR on cancer prevention is explored by reviewing reach articles retrieved from search engines and research articles depositories. Furthermore, Purdue University library was used to query the role of CR on cancer prevention treatment and its effect on lowering oxidative stress. More than 50 research articles were reviewed and the results of such review is explored hereafter.

3. Caloric Restriction and Cancer Prevention

The practice of calorie restriction as well as its possible function in the prevention of cancer have both been the topics of research in recent years. There are a number of fascinating discoveries that show there may be a relationship between calorie restriction and a lower risk of cancer. While the evidence is mostly based on preclinical studies [5] and observational data, this does not negate the significance of these findings.

Insulin and insulin-like growth factor 1 (IGF-1) both stimulate cell growth and proliferation, and studies have linked elevated levels of either of these hormones to an increased risk of developing a variety of malignancies. It has been shown that restricting calories may reduce insulin and IGF-1 levels, which in turn may aid to prevent the development and progression of tumors [3].

In addition, research has shown that restricting calorie intake is connected with metabolic changes that may have an effect on the development of cancer. It has been hypothesized that the metabolic changes generated by caloric restriction, such as enhanced cellular metabolism and lower oxidative stress, may limit DNA damage and mutations [17], hence decreasing the risk of cancer development. This theory is supported by the fact that caloric restriction has been shown to improve cellular metabolism. One such possible mechanism at play here is the effect that calorie restriction has on chronic inflammation. The formation and progression of several kinds of cancer are both significantly influenced by the presence of chronic inflammation. It has been shown that calorie restriction may lower levels of pro-inflammatory cytokines, which lends credence to the idea that it might assist in moderating the inflammatory response and perhaps inhibiting the formation of tumors [17].

Caloric restriction has been linked to the stimulation of autophagy, a process that inside assists in the removal of damaged organelles and proteins. Autophagy has been linked to the cancer prevention because autophagy may assist in the preservation of cellular homeostasis and may prevent the accumulation of toxic substances that might promote cancer. Although these processes provide logical explanations for the possible relationship between calorie restriction and the prevention of cancer, it is essential to keep in mind that the bulk of the evidence comes from research conducted on animals as well as data gathered from observations made by humans [7]. The number of controlled clinical studies that have been conducted expressly to investigate the effects of calorie restriction on the prevention of cancer in people is scanty; moreover, data that has been collected is contradictory [7].

Applying tight calorie restriction may be difficult and may involve significant hazards, such as nutritional deficits, particularly if the diet is not thoroughly planned and monitored [7]. It is essential to ensure that people who practice calorie restriction keep their nutritional intake at optimal levels in order to support their general health. Although the evidence suggests that there may be a potential association between calorie restriction and a reduced risk of cancer, additional research is required, particularly in controlled clinical trials, to establish a clear understanding of the specific effects of caloric restriction in human populations and to determine its feasibility [8]. When it comes to cancer prevention, it is important to maintain a diet that is well-balanced and rich in nutrients, in addition to addressing other aspects of one’s lifestyle, such as engaging in consistent physical exercise and avoiding tobacco use. Before beginning any kind of dietary restriction, it is highly recommended to seek the advice of healthcare experts or certified dietitians. In order to adopt an individualized and well-balanced approaches to nutrition and general health.
4. Caloric Restriction and Cancer Treatment

Cancer researchers have looked at the effects of caloric restriction, a dietary regimen that reduces total calorie intake without leading to malnutrition [12]. Although research on the impact of calorie restriction on cancer therapy is ongoing, some comments may be made. Studies in animals have shown that calorie restriction renders cancer cells more susceptible to chemotherapy and radiation therapy, two of the most common forms of cancer treatment [12]. Calorie restriction has the potential to alter tumor metabolism, slow the growth of tumor cells, and increase their responsiveness to therapy. However, further study is required to fully grasp the clinical significance and underlying processes of CR sensitization effect. In order to lessen the severity of treatment-related negative effects, caloric restriction has been suggested [12]. Side effects from cancer therapies are common and might include feeling tired, sick, and losing weight. By decreasing inflammation, oxidative stress, and metabolic changes, caloric restriction may help reduce some of these negative consequences. However, since people react differently to calorie restriction, it’s important to observe for undernourished [11].

Maintaining a healthy calorie intake during cancer therapy has been shown to increase both treatment tolerance and adherence [11]. Nutritional sufficiency has been shown to improve treatment results by bolstering the immune system, preventing muscular atrophy, and enhancing general well-being. However, thorough assessment of the patient’s unique demands and treatment regimen are required to determine the optimal calorie restriction and tailor nutritional assistance. Calorie restriction interacts differently with certain cancer types, treatment techniques, and patient characteristics, some of the many factors that must be taken into consideration. The viability and safety of calorie restriction during cancer therapy should be discussed with medical specialists, such as oncologists and certified dietitians. To ensure dietary requirements are satisfied and malnourishment are reduced, individualized nutritional advice and monitoring are essential [11].

Although there is hope for calorie restriction as a cancer therapy, more study is required to create recommendations, define the appropriate length and severity of caloric restriction, and identify patients that may have maximum benefit. To find the right balance between calorie restriction and nutritional requirements, individualized treatment regimens should be coordinated by healthcare providers and dietitians [8].

5. Caloric Restriction and Cellular Protection

Many research articles reviewed suggested the benefits of caloric restriction (CR) for promoting good aging and protecting cells (Fig. 2). Calorie restriction has been shown to protect cells by reducing reactive oxygen species (ROS) generation and by boosting the antioxidant defense system [15]. The damage caused by ROS to proteins, lipids, and DNA may lead to cellular malfunction and aging; CR helps protect cells from such damage. Improved DNA repair pathways is demonstrated after caloric restriction. By improving DNA repair, calorie restriction aids in preserving genomic stability and cellular integrity, both of which decline with age due to the build up of damaged DNA. The rate at which damaged organelles and proteins are degraded and recycled inside the cell, known as autophagy, has increased by CR. Autophagy is stimulated by caloric restriction and aids in the degradation of potentially hazardous compounds and the preservation of cellular homeostasis. Autophagy prevents toxic aggregates and defective organelles from building up inside cells by removing damaged components [16].

By increasing energy efficiency and decreasing metabolic waste, caloric restriction improves cellular metabolism. This metabolic improvement strengthens cells and makes them less vulnerable to damage by free...
The role of caloric restriction in cancer prevention, cancer treatment, and longevity

The longevity-associated pathways AMP-activated protein kinase (AMPK) and sirtuins (such as SIRT1) are activated by caloric restriction. Gene expression, energy metabolism, and cellular responses to stress are only some of the biological functions that are regulated by these pathways [14]. Caloric restriction enhances cellular defense and resilience by activating these mechanisms. Inhibition of pro-inflammatory signaling pathways and promotion of an anti-inflammatory milieu are the mechanisms through which caloric restriction reduces inflammation. Calorie restriction protects cells from inflammatory damage by lowering the chronic inflammation linked with age-related illnesses. It’s possible that the process by which caloric restriction protects cells from damage varies across species and cell types. In addition, studies are currently being conducted to determine the best calorie restriction intensity and duration for preventing cell damage [14].

6. Caloric Restriction and Surgical Stress Reduction

The effects of caloric restriction (CR) on postoperative stress and recovery have been investigated. Increased oxidative stress may harm tissues and slow recovery after surgery and anesthesia. Evidence [3] suggests that caloric restriction mitigates oxidative stress by lowering ROS generation and raising antioxidant defenses.

Organ function may be momentarily disrupted, and tissue damage may be induced during surgical operations. In animal studies, caloric restriction was reported to prevent organ damage. It may aid in organ preservation by boosting cellular stress resistance, decreasing inflammation, and maximizing cellular metabolism. Results from wound healing studies have shown that caloric restriction is beneficial [4]. Healing after surgery may be aided by CR because of its potential to reduce inflammation, boost tissue regeneration, and promote angiogenesis.

Improving immune response and decreasing postoperative infections, caloric restriction has been proven to alter immunological function. It’s possible that CR improves immune cell activity and helps maintain a healthy immunological balance. Reducing the risk of postoperative complications has been shown to be an additional benefit of caloric restriction before surgery. These consequences include infection, wound dehiscence, and anastomotic leakage. Possible processes include faster tissue repair, reduced inflammation, and increased resilience to stress [4].

Although caloric restriction may help reduce surgical stress, it should only be done so under the supervision of a medical practitioner during the perioperative period. In order to avoid malnutrition, it is important to carefully examine nutritional needs [4].

7. Caloric Restriction and Longevity

The lifespan-extending effects of caloric restriction (CR) have been thoroughly explored, and CR has been shown to work in a wide range of animals from yeast and worms to fruit flies and rats. Existing data shows that CR may have potential advantages for supporting healthy aging and prolonging lifetime in humans, while the direct effects of CR on human lifespan are being actively explored [15]. The processes by which calorie restriction increases lifespan are complex and yet poorly understood. Reference [10] have demonstrated that caloric restriction reduces ROS generation and increases antioxidant defenses. CR helps protect cells from oxidative stress, which may cause age-related decline and illness by damaging proteins, lipids, and DNA. Calorie restriction boosts cellular defenses by triggering processes including autophagy, enhanced DNA repair, and modification of stress response pathways. These functions safeguard cells from damage and malfunction that come with aging.

Enhancing insulin sensitivity, less inflammation, and increased mitochondrial efficiency may contribute to better metabolic health due to caloric restriction. These metabolic adjustments are linked to better health and longer life. Genes involved in aging and lifespan are turned on. The longevity genes and pathways AMP-activated protein kinase (AMPK) and sirtuins are both triggered by caloric restriction [1], [13], [18]. These genes control age-related biological processes, suggesting a role for CR in prolonging life expectancy. It’s worth noting that the timing and length of caloric restriction, as well as other variables, may influence the impact of CR on lifespan. The feasibility and possible hazards of long-term caloric...
Calorie restriction has been shown to have positive effects on cancer prevention, therapy, and cellular protection. Calorie restriction is now being studied as a possible complementary therapy for cancer treatment. More research, including well-designed clinical trials, is needed to confirm these findings and to elucidate the optimal strategies for implementing caloric restriction in the context of different cancer types and treatment modalities. While preclinical studies and some clinical evidence support the idea of improved treatment efficacy and reduced toxicities, more research is needed. In order to get the nutritional assistance and tailored treatment plans that are necessary for successful caloric restriction, it is important to proceed with caution and under the direction of healthcare specialists. To fully understand the impact of calorie restriction on human health and longevity, further long-term and well-controlled research on people are required in addition to the insights gained from animal studies. Finding the optimal balance in calorie restriction in humans is essential. Long-term calorie restriction in humans should be studied for any unintended consequences such as malnutrition and other negative health effects. Examine time-restricted eating and intermittent fasting as possible alternatives to conventional dieting in order to evaluate their health advantages and the likelihood of long-term adherence are recommended. Additional study is required to determine the molecular pathways by which caloric restriction promotes health. Targeted medicines or interventions may be possible if these pathways are understood.

8. Conclusion

Calorie restriction in people are still issues of current study, despite the fact that studies in non-human species have repeatedly demonstrated lifespan extension with caloric restriction. In order to prevent unfavorable outcomes like malnutrition or poor eating habits, it is important to note that calorie restriction should be undertaken cautiously and under the advice of healthcare specialists [2].

References