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Review

Importance of Nutrition Care During the Addiction Recovery Process

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Abstract

Food can help release and promote neurotransmitters. As a result, the food's effect in this regard is of great interest to individuals who have experienced dysregulation of the brain reward circuit due to addiction to drugs or other substances. This is one of the chief reasons why dietary choices can influence the success of drug addiction programs. While the general importance of nutrition was known previously—although it has been applied on few occasions—this review provides new knowledge that has emerged in recent years, which reinforces earlier findings regarding food's importance in overcoming addiction. In the last 15 years, there has been great progress in the understanding of the human intestinal microbiota, its importance for health, and its connections with the brain. However, since this area of nutrition is such a new field of study, it has rarely been applied to or considered in treatment programs. At the same time, it is important to avoid a diet based on ultra-processed foods, which deteriorate the microbiome and consequently harm the restoration of the natural reward system. Although ongoing research will undoubtedly provide a wealth of information in the coming years, the knowledge currently available is enough to confirm the importance of diet in a person's addiction recovery process. For this reason, it is important for patients and programs to follow a diet that regulates the brain's natural neurotransmitters through the microbiota and restores the natural functioning of the reward circuit, helping to overcome cravings.

Keywords: diet; neurotransmitters; educational programs; gut–brain axis; microbiota

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1. Introduction

Good nutrition is a fundamental requirement for maintaining health. However, in people with drug addiction, food consumption is often very limited, so nutrient deficiency, and even malnutrition, is a frequent occurrence—a phenomenon that also causes altered metabolism and dysregulation of hormones that control food intake and satiety [1]. In studies carried out, more than 60% of individuals with substance use disorders (SUDs) were found to suffer from multiple malnutrition [2], and 50% of all subjects were deficient in iron or vitamins [3]. For these reasons, most people in the process of recovery have developed severe nutritional deficiencies in proteins, fats, key vitamins, and minerals, and exhibit an impaired ability to effectively digest carbohydrates [2,3]. Some of these nutritional deficiencies are caused by the physical and biochemical changes directly resulting from drug and alcohol use, but they can also stem from poor dietary choices among individuals with SUDs and the abandonment of a nutrient-rich diet.

Drug users are a vulnerable population, and malnutrition can impede addiction recovery and promote drug-seeking behavior [4]. Despite these realities, most treatment

centers offer no guidelines or advice on the nutrition necessary for people in addiction recovery [1,4]. For this reason, it is important that treatment programs incorporate nutritional counseling in addition to conventional addiction recovery therapies [4].

Brain processes essential for survival are stimulated by both food—particularly sweets—and abused substances, and evidence has shown that a confusion between substance cravings and food cravings, known as addiction transfer, can arise during addiction recovery [4]. Notably, drug addiction triggers a series of changes in the neural circuits related to reward, motivation, conditioning, and control, while reducing the action of natural reinforcers (food, pleasurable natural situations, etc.) and diverting motivation almost entirely toward compulsive drug use [5]. As a result, interventions that enhance the action of non-pharmacological reinforcers (such as food) should be integrated into addiction treatment.

Over the last 15 years, researchers have made significant advancements in our understanding of the human intestinal microbiota, its importance for health, and its connections with the brain. The intestinal microbiota is composed of a large population of microorganisms—mainly bacteria, but also viruses, protozoa, and fungi [6]. The microbiome encompasses the entire habitat, including the microorganisms themselves, their genes, the surrounding environmental conditions, and the functions they perform. However, as this is a relatively new field of study, its potential as a support mechanism in addiction recovery has so far been largely overlooked. To address this gap, the objective of this work is to review the most recent scientific findings in order to assess the role that diet and the improvement of intestinal microbiota can play in the addiction recovery process.

2. Methods

A comprehensive literature search was conducted to explore the role of diet and the gut microbiota in individuals recovering from substance use disorders. The search was performed across scientific databases, primarily PubMed and Google Scholar. The following search terms and phrases were used: “diet”, “craving”, “reward system”, “brain neurotransmitters”, “nutrition”, “addiction recovery”, “effects of nutrients on the nervous system”, “food reward”, “drug addiction”, “microbiota-gut-brain axis”, “nutrition and recovery from substance use disorders”, “gut microbiome”, “food addiction”, and “education on nutritional behavior in drug treatment”.

Search Strategy and Selection Criteria. The search was limited to articles published within the last 20 years to ensure the inclusion of the most recent and relevant research. The inclusion criteria were as follows: (1) original research articles, reviews, or meta-analyses that addressed the relationship between diet, microbiota, and recovery from substance use disorders; (2) studies involving human subjects; and (3) articles written in English. Exclusion criteria included the following: (1) studies not directly related to the gut–brain axis or nutrition in the context of addiction recovery; (2) articles focusing solely on animal models without translational relevance; and (3) conference abstracts, editorials, or opinion pieces.

Study Selection and Review. A total of 310 articles were initially identified through the database searches. After screening titles and abstracts for relevance, 98 articles were selected for full-text review. Of these, 48 studies met the inclusion criteria and were included in the final narrative review. Data extracted from these studies included study design, sample size, and key findings related to diet, microbiota, and recovery outcomes.

Data Synthesis. A narrative review was performed during 2024 to summarize the most significant findings regarding the impact of diet and microbiota on recovery from substance use disorders, highlighting potential mechanisms and implications for treatment.

3. Results

3.1. Neurobiological Foundations

3.1.1. The Relationship Between Food and the Brain

Animal and human research has provided sufficient evidence that specific neuroendocrine systems modulate the consumption of certain nutrients, influencing an individual's metabolism and weight gain or loss [7]. Furthermore, neurotransmitters are synthesized in the brain from nutrient-derived precursors, with the amino acids found in protein-rich foods playing a particularly important role in this process. When the diet lacks essential nutrients, as is often the case for individuals recovering from substance use disorders (SUDs) [2,3], an adequate amount of neurotransmitters is not produced. This imbalance can disrupt brain function, mood, and behavior, leading to cravings.

For example, the release of serotonin in brain neurons is closely linked to dietary intake [8]. Carbohydrate consumption contributes to serotonin release in the brain by stimulating insulin secretion and increasing the relative concentration of tryptophan in the bloodstream [8]. Serotonin plays a key role in several central nervous system functions, including sleep regulation, blood pressure, eating behavior, pain perception, and mood [8,9].

Thus, the food we consume affects the chemical composition of the brain and influences our emotional state. In simple terms, nutrition impacts cognitive functions, including alertness and the synthesis or release of neurotransmitters [10]. Numerous epidemiological studies have indicated a high prevalence of mental health issues—such as depression and anxiety—among individuals with substance use disorders, and these conditions often hinder recovery and increase the likelihood of relapse [1,4]. Some foods can have drug-like effects, potentially leading to dependency, and may be used to cope with depression, menstrual stress, or the stress associated with smoking cessation (like carbohydrates, nicotine also promotes serotonin release in the brain) [8].

Essential nutrients play a critical role in regulating mood through their effects on brain chemistry [4]. In particular, amino acids such as tryptophan, phenylalanine, and tyrosine are essential for the synthesis of neurotransmitters like serotonin, dopamine, and norepinephrine [4], and available evidence indicates that a balanced diet can help reduce symptoms of depression [9].

3.1.2. Similarities and Differences Between Drug and Food Addiction

Evolutionary pressures that favored behaviors essential for survival have shaped feeding circuits to promote food intake [11]. However, drug use can hijack the neural circuits involved in processing natural rewards, inducing plastic changes that enhance drug seeking and craving as addiction progresses [12].

For example, there is substantial evidence showing an increased preference for sweets among drug users [1]. This is likely because the reinforcement systems for drug use and sweet food share common reward pathways in the brain [4]. As a result, repeated and excessive sugar intake can lead to brain and behavioral changes that closely resemble the effects of drug use. Under certain conditions, sugar may have addictive properties similar to those of drugs [13].

Eating behavior is regulated by several processes involving two interacting neural circuits: a homeostatic system, which manages energy balance and food intake based on the body's energy needs, and a reward-based system influenced by pleasure and learned experiences [6,12]. These two systems are integrated and coordinated by the hypothalamus [6]. Neuroregulation of these processes involves a complex network that overlaps with the neural pathways engaged by addictive substances and behaviors [6]. Neuropeptide systems that regulate appetite and satiety may also influence responses to drugs, although the underlying mechanisms differ in each case [11]. Some individuals

may develop abnormal food cravings, particularly for highly palatable foods that strongly activate the brain's reward circuitry [6]. Nevertheless, the neurobiological differences between how food and drugs drive addictive behavior are not yet fully understood. While both activate the reward system, they do so in distinct ways [11].

As previously noted, addictive disorders are often accompanied by poor nutritional status and even disordered eating. It is common for individuals in recovery to experience gastrointestinal discomfort and a marked preference for highly palatable foods that are low in fiber and essential nutrients [14]. During the early stages of recovery, particularly during detoxification and while receiving pharmacotherapy, patients frequently report low food intake due to nausea, anorexia, and digestive issues that interfere with eating [1].

Between the first and sixth month of detoxification, individuals commonly display a strong preference for sweet foods as a substitute for drugs, while consuming minimal amounts of fruits and vegetables. Among heroin users, sugary foods appear to be especially preferred, and this preference may reflect addictive tendencies. In fact, some studies indicate that heroin users experience cravings for sweets more intensely before using the drug than afterward [1]. From the sixth month onward, sugar cravings tend to stabilize, with patients showing more structured eating patterns and improved appetite [1]. Initially, palatable foods may act as strong reinforcers compared to drugs, but the development of addictive behavior from substances like cocaine may be linked to the formation of more persistent associations than those formed with natural reinforcers such as food [11].

3.2. Microbiota Dysregulation in Addiction

3.2.1. Relationship of the Intestinal Microbiota with the Brain Reward Circuit

There is sufficient evidence demonstrating the potential of the endocrine and immune systems to modulate the brain's reward circuit. However, in the last 15 years, another key factor has emerged: the intestinal microbiota, which is composed of bacteria and other microorganisms residing in the gut. These microorganisms are involved in regulating the reward system and influence feeding behavior, social interaction, and addiction-related behaviors [6,12]. In particular, growing evidence indicates that gut microorganisms significantly affect eating habits and reward-seeking behaviors [6,12].

Recent years have seen major advancements in our understanding of the bidirectional communication between the microbiota and the central nervous system, especially the reward system. This system can be stimulated by natural reinforcers, such as food, social interactions, and sexual activity, as well as by unnatural reinforcers, including alcohol, psychostimulants, opioids, and cannabis [12]. The brain and the intestinal microbiota are interconnected in both directions: the brain regulates intestinal activity, and the gut can in turn influence brain function, contributing to overall physiological balance. One of the most important communication pathways in this system is the vagus nerve. Due to this tight interconnection, both the brain and microbiota can influence behavior, with microorganisms producing beneficial effects and modulating anxiety-related responses [6,12]. In addition, the microbiota plays a role in regulating the immune system [12].

Evidence has shown that individuals with substance use disorders (SUDs) are more likely to experience depression, and the intestinal microbiota is one of the body's primary sources of neurotransmitters [6]. Therefore, improving one's diet may reduce depressive symptoms through positive changes in the microbiota [14]. To explore this dynamic, several studies have compared "traditional" diets, such as the Mediterranean and Japanese diets, with the "modern Western" diet, finding that the risk of depression is 25–35% lower among people who follow traditional dietary patterns. Researchers attribute this difference to variations in dietary intake. Traditional diets are generally rich in vegetables, fruits, whole grains, and seafood, and include moderate amounts of lean meats and dairy products [15].

They also tend to exclude processed and refined foods and added sugars, which are common in Western dietary patterns [15]. Many unprocessed foods in traditional diets are fermented and act as natural probiotics, since fermentation uses bacteria and yeast to convert food sugars into carbon dioxide, alcohol, and lactic acid [15]. Collectively, these characteristics contribute to the positive effects of traditional diets on gut microbiota health.

3.2.2. Substances That Impair Gut Microbiota and the Brain Reward Circuit

Current evidence suggests that disruptions in the gut microbiota induced by psychoactive substances are associated with alterations in the brain's reward response, underscoring the need for further research into how microbiome imbalances may contribute to drug-seeking behavior [12]. Several brain regions have been identified in which gut microbiota influence dopaminergic neurotransmission, indicating that dopaminergic circuits are particularly sensitive to changes in the gut microbiome [12]. Gut dysbiosis—defined as a disruption in the composition or function of the microbiota—alters neuromodulator levels through microbiota–brain communication pathways and may be a contributing factor in maladaptive behaviors, including food addiction [6]. Furthermore, dysregulation of the intestinal microbiota affects intestinal permeability, facilitating the entry of microbial metabolites—some of which can be toxic—into the bloodstream. These metabolites can modulate host behavior, which helps explain why many central nervous system disorders are associated with a compromised intestinal barrier [6].

Highly palatable and ultra-processed foods stimulate the reward system in ways that closely resemble the effects of drugs, triggering similar neuroadaptive responses. These responses can subsequently alter eating behaviors and lead to the development of food addiction [12].

In addition, brain disorders associated with aging may partly result from dietary deficiencies in antioxidants and essential nutrients, including trace elements, vitamins, and non-essential micronutrients such as polyphenols, which protect against oxidative stress caused by free radicals [16]. Dietary factors thus play a significant role in determining whether the brain ages healthily or develops neurodegenerative conditions, highlighting the potential for food to negatively affect brain function [17].

3.2.3. Impaired Gut Microbiota Due to Drug Use

It is important to recognize that not all addictions or substance use disorders (SUDs) can be treated as a single entity. Each SUD constitutes a distinct disease process with its own neurobiological, psychological, and social characteristics. Therefore, impairments in gut microbiota associated with drug use should be understood within the context of specific substances and their unique effects, rather than generalized across all types of addiction.

Alcohol. Numerous studies have examined the relationship between gut microbiota and alcohol use disorders [12,18–24]. Chronic alcohol consumption has been linked to alterations in gut permeability and microbiome composition, both of which have also been associated with increased craving. For example, alcohol-dependent individuals show a significant reduction in *Firmicutes* and an increase in *Bacteroidetes* compared to non-drinkers, with effect sizes of Cohen's d = 0.8 in microbiome diversity [12]. A study by Bjørkhaug et al. [25] revealed that alcohol reduces the relative abundance of Actinobacteria phylum, class Clostridia, and *Faecalibacterium* genus, while increasing the relative abundance of Proteobacteria phylum, *Sutterella* genus, *Holdemania* genus, and *Clostridium* genus in patients with over 10 years of alcohol overconsumption. Another study by Mutlu et al. [26] found that continued alcohol consumption elevates the relative abundance of Proteobacteria phylum, Firmicutes, and Gammaproteobacteria class, and decreases the

relative abundance of Bacteroidetes phylum, Verrucomicrobia phylum, Clostridia class, Bacteroidetes class, and Verrucomicrobiae class. These microbial shifts contribute to dysregulation of the gut–brain axis and may underlie some behavioral aspects of addiction.

Cocaine. The gut microbiota influences cocaine-seeking behavior [12]. In addition, individuals who use cocaine tend to follow irregular eating patterns, often relying on late-night meals that are typically high in refined carbohydrates and fats and low in fruits and vegetables [1]. Consistent with this diet, a significant reduction in beneficial bacteria such as *Lactobacillus* and *Bifidobacterium* was observed in cocaine users (mean difference = −2.1, $p < 0.05$) [1]. Furthermore, intake of essential vitamins and minerals in this population is often below recommended levels, with approximately 65% of cocaine users showing deficiencies in key micronutrients [1].

Opioids. Poor nutritional status among opioid-dependent individuals is well documented. Users of heroin and cocaine tend to have lower energy and protein intake than non-users. Frequently, opioid users replace protein- and fat-rich foods with meals high in sugar and alcohol content, which lack essential nutrients [1]. Protein intake appears to decline with both increased intensity and duration of drug use [1]. In the short term, opioids can cause anorexia, reduced food intake, and diminished gastrointestinal motility, all of which contribute to malnutrition and elevated risk of infection in the long term [1]. Preliminary research indicates the importance of considering nutritional risks early in treatment, particularly for opioid users [27]. Specifically, opioid-dependent individuals with high nutritional risk were 2.2 times more likely to drop out of methadone treatment compared to those with low or moderate risk (HR = 2.2, 95% CI: 1.5–3.0) [27]. Additionally, opioid use has been shown to reduce gut microbiota diversity by approximately 15% compared to controls, further compromising gut–brain communication [12].

Cannabinoids. Cannabis use affects the abundance and diversity of the gastrointestinal and vaginal microbiota [28]. Chronic consumption of tetrahydrocannabinol (THC) has been shown to modify the gut microbiota in animal models, with observed reductions in microbial diversity by around 16% [12,28]. However, human data remain limited, and further research is needed to quantify these changes and understand their implications.

Tobacco. Smoking alters the composition of the gut microbiota, increases mucosal permeability, and impairs immune function, although the exact mechanisms underlying tobacco-induced dysbiosis remain unclear [29]. Notably, tobacco use is associated with a reduction in bacterial diversity in the fecal microbiota of smokers of about 30% compared to non-smokers, along with an increased prevalence of the genus *Prevotella* [30].

Psychotropics and Antidepressants. Pharmacological treatments, particularly antidepressants, can significantly alter the gut microbiota. Many of these drugs have antimicrobial properties, and studies in animals have shown that chronic administration of antidepressants reduces microbiota diversity and richness by approximately 20% [31].

Hallucinogens. Substances such as psilocybin and tryptamines also affect microbiome composition and diversity [32]. In one study examining the relationship between gut microbiota and toxicity caused by narcotics and psychodysleptics, nine microbial groups—mainly from Class *Negativicutes* and Order *Selenomonadales*—were found to be strongly associated [33]. Hallucinogen use was linked to a 22% increase in *Negativicutes* and a 15% decrease in *Firmicutes* diversity [33].

Although these associations are well documented, further research is needed to elucidate the mechanisms by which gut dysbiosis influences the brain's reward circuitry. Future studies should explore whether drug use is the primary driver of microbiota alterations or, conversely, whether the microbiota contributes to the development and maintenance of addiction by influencing reward-related pathways [12].

3.3. Nutritional Interventions and Recovery

3.3.1. Substances That Improve the Intestinal Microbiota and the Reward Circuit

As discussed above, substance use disorders (SUDs) can cause various adverse health effects, including nutritional deficiencies and malnutrition. Physical exercise is important for improving health and has a beneficial effect on the release of serotonin and other brain neurotransmitters involved in the reward circuit. Although factors such as diet and exercise can have synergistic effects and indirectly support the intestinal microbiota, this section focuses on compounds that directly benefit the microbiome and the reward circuit (Table 1).

Table 1. Summary of Evidence Quality for Each Intervention.

Intervention	Key Evidence	Evidence Quality	Comments
Prebiotics	Improvement of the gut microbiota and effects on depression, anxiety, and addiction through bacterial metabolites.	Moderate	There are studies supporting the effects, but more research is needed on the exact mechanisms.
Probiotics	Effects on obesity treatment, autism, and anxiety. Increased brain activity in areas related to emotional processes.	Moderate	There is evidence of positive effects, but more research is needed on the direct impact on substance addiction.
Micronutrients (supplements)	Impact on mood regulation, focusing on serotonin, and effects on depression.	High	Strong studies show that micronutrient deficiencies affect mental health, and supplementation shows positive results.
Amino Acids (tryptophan, tyrosine, etc.)	Reduction in opiate cravings during detoxification.	Moderate	Amino acid supplementation shows a reduction in drug cravings, but more high-quality studies are needed to confirm these effects on addiction.
Omega-3 Fatty Acids	Improvement in mental health and reduction in relapse during addiction treatment.	Moderate	Promising, but the evidence is not definitive yet.
Vitamins and Minerals	Supplementation related to improved mood and reduction of depression.	High	Solid studies back the importance of these vitamins in mental health, particularly in preventing relapse during treatment for addiction.

Prebiotics are compounds indigestible by humans but utilized by intestinal microorganisms. These compounds can modify the microbiota and metabolism, conferring health benefits at the physiological level of the host [12]. Regarding the brain, prebiotics can influence behaviors associated with depression, anxiety, and addiction, among others, with their beneficial effects being mediated by bacterial metabolites [12]. Studies on prebiotics and their relationship to mental health are promising, but the exact mechanisms are still unclear. Some human trials have shown positive effects, but overall evidence is considered moderate [34,35].

Probiotics, on the other hand, are live bacteria which, when ingested in adequate quantities, exert beneficial effects on the host's health. They have shown positive effects in treating obesity and improving conditions on the autism spectrum. However, much remains unknown about the underlying mechanisms through which "psychobiotics" [12] influence host physiology and behavior. Regarding drug addiction, little is known about the specific role probiotics may play, but their consumption has been linked to changes in activity in

several brain areas involved in emotional processing [6]. People who take probiotics tend to exhibit reduced anxiety levels, improved stress perception, and better mental outlook compared to those who do not [15]. While the direct effect of probiotics on drug addiction has not been clearly identified, these associated benefits suggest early promise. While probiotics have shown positive effects on the gut microbiota and mental health (anxiety, depression), the direct link to substance addiction is still somewhat uncertain. Thus, the evidence is moderate [34,36].

Additionally, essential **micronutrients**—often consumed as recommended supplements—play a significant role in regulating mood. Deficiencies or insufficient intake of these nutrients, along with food deprivation, correlate with poor mental health, especially depression [1]. A crucial link between micronutrients and neurological benefits involves serotonin. Serotonin modulates many behaviors, including violence, aggression, mood, sleep, and appetite [1]. Although serotonin is present in some fruits and vegetables, it barely crosses the blood–brain barrier. However, the amino acid tryptophan, which easily crosses this barrier, modulates serotonin synthesis in the central nervous system [9]. Therefore, a tryptophan-rich diet may be important for patients susceptible to drug addiction by modulating these behaviors [1]. Micronutrient supplementation has known benefits, such as mood improvement, which increases the evidence quality [34,37].

Other nutrient-related substances also play important roles. Tyrosine increases the production and release of the neurotransmitter dopamine and norepinephrine. Additionally, phosphatidylcholine found in some foods (such as liver and eggs) is rapidly hydrolyzed in the intestinal mucosa to form free choline. Consequently, consuming adequate amounts of phosphatidylcholine increases choline levels in plasma and the brain, activating choline-acetyltransferase, the enzyme that produces the neurotransmitter acetylcholine [38]. Micronutrients are also necessary cofactors for the synthesis of serotonin, dopamine, and catecholamines. Plasma levels of tryptophan, tyrosine, and choline vary depending on diet, and all three freely cross the blood–brain barrier [38]. Tyrosine and phenylalanine are also involved in dopamine and catecholamine synthesis, which influence behavioral performance [1].

Although no general consensus yet exists on the efficacy of these precursors in treating drug use, opiate-addicted patients given a combination of amino acids (phenylalanine, tryptophan, tyrosine, and glutamine) during detoxification show a significant reduction in opiate craving [1]. This suggests it may be an important tool in drug treatment programs. While some studies show that amino acid supplementation can reduce opiate cravings, more research is needed to confirm these results, especially in the context of substance addiction [34].

Furthermore, mineral and vitamin deficiencies have been linked to depression. Supplementation with vitamins and minerals (such as zinc, magnesium, and the B-complex vitamins) is well-supported by studies, especially in relation to mental health and depression treatment. This makes the evidence quality high [34,37]. For this reason, vitamin and mineral supplementation should be integrated into drug treatment programs, not only to manage malnutrition but also to help prevent relapse [1].

Indeed, the intake of specific nutrients such as amino acids and omega-3 fatty acids has shown promise in improving mental health and reducing relapse during treatment; however, further high-quality studies are needed to provide clear evidence that such supplementation enhances the effectiveness of drug-related treatments [1]. The evidence is still considered moderate because the results are mixed [34,36].

3.3.2. Importance of Nutrition Education Programs

Although there has been growing interest in the role of nutrition in the recovery of people with substance use disorders (SUDs), only a few small-scale, targeted nutrition interventions have been implemented so far, and few treatment centers offer any nutrition services [39]. When implemented, simple nutrition education about healthy eating habits improves the quality of nutritional intake for individuals with drug addiction. To ensure maximum efficacy, interventions should include rigorous nutritional assessments during treatment and targeted follow-up [4]. Importantly, education about the importance of good nutrition is often poorly implemented [40], despite the fact that improving nutrition early in treatment has the potential to enhance mental health and overall recovery outcomes [39]. For these reasons, among others, it is crucial to utilize available nutritional and psychological knowledge to support recovery.

Positive associations have been found between nutrition education programs and favorable outcomes in SUD treatment programs [41]. Some authors suggest that individualized nutritional interventions may specifically improve treatment outcomes for opioid and alcohol users [39]. Studies have shown that nutritional therapy can greatly benefit individuals with opioid use disorders, not only by improving their nutritional habits but also by enhancing their social environment [42]. While opioid and alcohol users are often considered at high nutritional risk, most treatment centers do not provide nutritional advice or support [39]. For patients undergoing methadone maintenance treatment, interventions to improve nutrition knowledge and promote healthy eating habits are also recommended to reduce diet-related morbidity. Nutrition knowledge appears to influence dietary choices in this population. For example, when nutrition education was provided as part of a program, participants consumed healthier foods and ate more meals [1]. All individuals with drug and alcohol use disorders in rehabilitation programs can benefit from consuming foods with high nutritional value to help balance their microbiota. In fact, the implementation of an educational intervention aimed at increasing knowledge about healthy eating styles in patients with alcohol dependence contributed to improving their nutritional status [43].

Overall, there is evidence that nutrition-related educational and environmental interventions can be successful despite the numerous challenges faced by residential substance use treatment centers [44]. For these reasons, recovery programs for SUDs should consider incorporating a nutritionist or dietician as a member of the treatment team, which may contribute to improved clinical outcomes [39].

3.4. Special Populations and Considerations

Gender Perspective

It is important to note that many changes associated with the microbiota occur in a sex- and gender-dependent manner, and these differences can influence the brain and resulting behavior [6]. For instance, women report greater food addiction behaviors, cravings, and need for reward than men—findings that have also been observed in relation to drugs [45]. For this reason, the close interaction between the microbiota and sex/gender should be considered in future studies and drug treatment programs [6].

Moreover, weight gain has been especially observed among women undergoing drug treatment, potentially increasing their risk of relapse [1]. Some studies have shown that weight loss can be a highly motivating and reinforcing side effect of drug use among women [46]. Relatedly, some authors argue that one reason for increasing rates of SUDs in women is related to weight concerns: women increasingly report that weight loss is their main reason for using legal or illegal drugs [46]. Notably, women are five times more likely than men to attribute the initiation of drug use to a desire to lose weight [46]. For this reason, pre-assessment of weight-related concerns in women entering substance use

treatment may be important to identify the severity of these concerns and to address how they may influence each individual's treatment. A longitudinal program that includes physical activity and nutritional oversight is needed to account for motivating factors related to weight [47].

Gottfredson and Sokol [48] found no evidence to support the Addiction Transfer Hypothesis, which suggests that cravings lead to non-nutritive eating during recovery. However, there was modest support for the Propensity for Behavioral Addiction Hypothesis, indicating that individuals with a higher tendency for addictive behaviors may be more prone to excessive weight gain. The authors recommend nutrition education and promotion of healthy eating habits to help reduce weight gain in people recovering from SUDs. As we have seen, this can be especially important for women.

4. Discussion and Conclusions: Nutritional Care, Microbiota, and Educational Programs

The foods we eat directly affect the chemical composition of our brain and alter our mood. In this way, some foods can resemble drugs, creating a comparable dependency, while others can be used to benefit individuals' physical and mental health. More specifically, highly palatable and ultra-processed foods activate the reward system, triggering adaptations similar to those induced by drug use. The underlying neurobiology that explains the differences in the capacity of food and drugs to drive addictive behavior is not yet fully understood; although there are commonalities, there are also differences in the responses to food and drugs at the level of the reward system.

We do know, however, that microorganisms in the intestine are involved in the regulation of the reward system, influencing eating, social, and addictive behaviors. Moreover, intestinal dysbiosis (dysregulation of the microbiome) alters the levels of neuromodulators through the connections between the intestinal microbiota and the brain.

Drug use, meanwhile, alters the composition of the microbiota, reducing the richness of the species present as well as their diversity. Conversely, prebiotics, probiotics, and other supplements and micronutrients collaborate to restore the microbiome and balance the reward system and neurotransmitters in the brain.

In recent years, much knowledge has been generated about the reward circuit, though more research is necessary to understand it fully. Significant evidence has accumulated on the important role that the microbiome plays in modulating the natural reward system in general and, in particular, in the area of the reward system compromised by substance use. There is therefore significant potential for treating these problems through the improvement of the microbiome. This therapeutic intervention has become known as psychobiotics [12]. Although ongoing research will undoubtedly provide information of great interest in the coming years, our extant knowledge allows us to confirm the importance of diet in the addiction recovery process [12].

For this reason, nutritional education for people who use drugs or who are undergoing treatment for recovery from SUDs is currently underutilized. To address this shortcoming, dietitians should promote and encourage the inclusion of nutritional education in substance use treatment programs, as fully integrated programs are needed to provide adequate and comprehensive nutritional care to drug users in treatment centers.

One avenue for future research concerns the differences between various cultural environments and diet types, such as differences between American, European, and Eastern diets, and their influence on the microbiome and recovery from addictions. While "traditional" diets have been shown to be more beneficial in this regard, more research is needed to understand these differences and their mechanisms more fully. It would also be beneficial to assess the effects of nutrition in the treatment of drug users in relation to

age to identify whether nutrition and microbiota affect people differently based on age. Lastly, more can be learned regarding the broader relationship between the brain and the microbiome. In many cases, it is still unknown whether it is the brain that acts on the microbiota or, on the contrary, the microbiota that influences the brain, especially in the case of mental illnesses. It is quite likely that the interrelation occurs in both directions, but more research is necessary to establish this bidirectionality and its inner workings.

4.1. Evaluation of Evidence Quality and Current Limitations

It is important to acknowledge that much of the evidence supporting the relationships between microbiota, nutrition, and addictive behaviors comes from observational studies. While these studies provide valuable insights, they do not establish causal relationships definitively. Most of the current research is preliminary and often lacks controlled experimental designs, such as randomized controlled trials, which are necessary to confirm the efficacy of nutritional interventions in addiction recovery. Additionally, heterogeneity in methodologies, populations studied, and variables analyzed complicates the comparison of results and the formulation of firm conclusions. Therefore, although existing findings suggest a potential link between microbiota and reward pathways, these should be interpreted with caution, recognizing the inherent limitations of the current evidence base.

4.2. Publication Bias and Contradictory Findings in the Literature

Another important consideration is the potential for publication bias, where studies showing positive or significant results are more likely to be published than those with null or negative findings. This bias can create an overly optimistic view of the effectiveness of nutritional strategies and microbiota modulation in addiction treatment. Furthermore, the literature contains studies with conflicting results regarding the magnitude and nature of these effects. Some research reports no significant differences in microbiota composition or clinical outcomes following dietary interventions, indicating that the relationship remains inconclusive. Future reviews and studies should address these discrepancies, analyze possible reasons for inconsistencies, and adopt a more balanced and critical perspective.

4.3. Efficacy of Nutritional Interventions and Recommendations for Future Research

While the hypothesis that microbiota modulation through nutritional interventions may benefit addiction recovery is promising, the current evidence supporting their efficacy remains limited and preliminary. Most available studies are short-term, involve small sample sizes, and lack appropriate controls, making it difficult to draw definitive conclusions about their clinical impact. Consequently, claims regarding the effectiveness of nutritional strategies should be presented with greater caution, emphasizing the need for well-designed, large-scale randomized trials to validate these approaches. Until more robust evidence is available, recommendations should focus on promoting balanced diets and integrating nutritional education into treatment programs, without overstating their current benefits.

4.4. Conclusions

In summary, although the relationship between microbiota, diet, and addiction is an emerging and exciting field with encouraging preliminary results, it is crucial that conclusions reflect the limitations of the existing evidence. Overgeneralizations should be avoided, and the need for further rigorous research emphasized. Continued investigation through controlled experimental studies is essential to clarify underlying mechanisms and establish the true efficacy of nutritional interventions in addiction recovery. Only with solid evidence can we develop reliable, evidence-based recommendations to improve therapeutic strategies in this area.

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