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KETOGENIC DIET IN PSYCHIATRY: APPLICATION IN TREATING DEPRESSION AMONG ATHLETES

Paulina Kumięga
Medical University of Warsaw
https://orcid.org/0009-0005-1431-0231
Zuzanna Kudas
Medical University of Warsaw
https://orcid.org/0009-0009-6750-6886
Nikola Perchel
Medical University of Warsaw
https://orcid.org/0009-0005-6489-7480
Aleksandra Litwin
Medical University of Warsaw
https://orcid.org/0009-0004-3221-0085
Karolina Krzywicka
SPKSO Ophthalmic University Hospital in Warsaw, Józefa Sierakowskiego 13, 03-709 Warszawa, Poland
https://orcid.org/0009-0001-3248-4674

Paweł Nowocin
Medical University of Warsaw
https://orcid.org/0009-0007-2018-6139
Piotr Wasiński
Medical University of Warsaw
https://orcid.org/0009-0009-3824-3618
Natalia Dąbrowska
Medical University of Warsaw
https://orcid.org/0009-0009-7170-0614
Martyna Koszyk
Uniwersytet Kardynała Stefana Wyszyńskiego w Warszawie
https://orcid.org/0009-0000-9927-6020
Dawid Kulczyński
Medical University of Warsaw
https://orcid.org/0009-0003-3897-1507

Abstract

Depression is a prevalent mental health challenge, particularly in athletes, where the interplay of high-performance demands, physical stress, and injury exacerbates psychological vulnerabilities. Emerging evidence suggests that the ketogenic diet (KD), a high-fat, moderate-protein, and low-carbohydrate dietary intervention, holds therapeutic potential for managing depression. KD induces ketosis, a metabolic state that enhances brain energy metabolism, reduces neuroinflammation, and stabilizes neurotransmitter function, all of which are implicated in the pathophysiology of depression.

This review synthesizes findings from recent clinical trials, meta-analyses, and case studies focusing on KD's neurological and psychological effects. The results indicate significant improvements in depressive symptoms, mood stabilization, and mental resilience among individuals adhering to KD. Moreover, KD’s modulation of the gut-brain axis introduces an

additional pathway for improving mental health by fostering a diverse gut microbiome and reducing systemic inflammation.

For athletes, KD offers dual benefits: alleviating depressive symptoms while supporting cognitive function and recovery. However, adherence to the diet and potential side effects such as fatigue and gastrointestinal discomfort pose challenges. Current research is limited by a lack of large-scale, randomized controlled trials specifically targeting athletic populations.

In conclusion, KD demonstrates promise as an adjunctive therapy for depression in athletes. Its multifaceted effects on brain health and performance metrics underscore its potential role in sports psychiatry. Further research is necessary to optimize KD protocols and establish evidence-based guidelines for its clinical application in athletic populations.

Keywords: Ketogenic diet, depression, athletes, psychiatry, mental health.

Introduction

Depression is a prevalent mental health disorder characterized by persistent low mood, loss of interest in activities, and cognitive and physical impairments. Among athletes, the condition is exacerbated by the high-performance demands, stress, and potential consequences of overtraining or injury. Effective therapeutic strategies are crucial for addressing depression in this unique population. Recent research has highlighted the potential of dietary interventions, particularly the ketogenic diet (KD), as a novel approach for managing depression and enhancing mental health outcomes (Marx et al., 2021; Chrysafi et al., 2024).

The ketogenic diet, a high-fat, moderate-protein, and low-carbohydrate dietary regimen, induces a state of ketosis wherein ketone bodies serve as an alternative energy source for the brain. This metabolic shift is associated with several neuroprotective benefits, including

reduced neuroinflammation, improved mitochondrial function, and enhanced neurotransmitter regulation (Ricci et al., 2020). These mechanisms align with the pathophysiological underpinnings of depression, suggesting KD's viability as a therapeutic option for individuals experiencing mood disorders (Bear et al., 2020; Mrozek et al., 2023).

Athletes, who are frequently subjected to psychological and physical stress, present a unique subset of individuals who may benefit from the mental and physical advantages of KD. Studies indicate that the gut-brain axis plays a significant role in mood regulation, with dietary patterns modulating the gut microbiota and influencing neuroinflammatory processes (Taylor et al., 2020; Martin et al., 2023). Furthermore, KD has demonstrated efficacy in alleviating depression symptoms and improving emotional well-being across diverse populations, including those with neurodegenerative diseases and chronic stress conditions (Tidman et al., 2024; Włodarczyk et al., 2021).

The relationship between diet and mental health is increasingly supported by empirical evidence. Emotional eating behaviors, dietary quality, and the impact of specific nutrients on mood and cognition are well-documented (Braden et al., 2018; Kumar & Shah, 2021). Among dietary strategies, KD stands out for its ability to stabilize blood glucose levels, reduce oxidative stress, and support brain energy metabolism (Garner et al., 2024; Marx et al., 2021). These effects may be particularly beneficial for athletes, whose mental health is intricately tied to their physical performance and recovery.

This paper aims to explore the application of the ketogenic diet in treating depression among athletes, synthesizing findings from recent studies on KD's neurobiological, psychological, and metabolic effects. By examining the underlying mechanisms and clinical evidence, the study seeks to evaluate KD's potential as an adjunctive therapy for depression in this population. Special attention is given to the unique challenges faced by athletes and how KD may address these through its holistic impact on physical and mental health. Ultimately, this research contributes to the growing body of evidence supporting the integration of dietary interventions into psychiatric practice for targeted populations.

Methods

This study employs a comprehensive review methodology to evaluate the application of the ketogenic diet (KD) in treating depression among athletes. The methods include a systematic literature search, selection of relevant studies, and synthesis of findings.

A systematic search was conducted in major academic databases, including PubMed, Scopus, and Web of Science. The search utilized a combination of keywords such as "ketogenic diet," "depression," "mental health," "athletes," and "sports performance." Boolean operators (AND/OR) were applied to refine the search and ensure relevance. Articles published between 2018 and 2024 were prioritized to capture the latest developments in the field. To further enhance the search scope, references cited in key articles were reviewed.

Studies were included if they met the following criteria:

1. Focused on the ketogenic diet and its effects on depression or mental health.
2. Examined the athletic population or other physically active individuals.
3. Provided empirical evidence, such as clinical trials, systematic reviews, meta-analyses, animal studies, or case studies.
4. Published in peer-reviewed journals and written in English.

Studies were excluded if they:

1. Discussed the ketogenic diet without addressing mental health outcomes.
2. Focused solely on non-athletic populations without generalizable findings.
3. Were editorials, opinion pieces, or lacked empirical data.

The reviewed studies included a mix of methodologies, providing a multidimensional understanding of KD's impact on depression:

1. **Clinical Trials**: Randomized controlled trials and longitudinal studies investigating KD's effectiveness in improving depressive symptoms were analyzed. These studies provided robust data on mood regulation, neurobiological changes, and patient-reported outcomes (e.g., Chrysafi et al., 2024; Garner et al., 2024).

2. **Animal Models**: Preclinical studies exploring the mechanistic pathways of KD in animal models of depression were included. These studies offered insights into KD's effects on neuroinflammation, oxidative stress, and neurotransmitter modulation (e.g., Gumus et al., 2022; Ricci et al., 2020).
3. **Case Studies**: Individual case studies highlighted unique applications of KD in clinical contexts, such as its role in neurodegenerative diseases and mood stabilization. These studies served as exploratory evidence for its potential in specialized populations, including athletes (e.g., Tidman et al., 2022).

Data from the selected studies were synthesized qualitatively to identify recurring themes, patterns, and gaps in the literature. The focus was on understanding KD's neurobiological and psychological effects, with an emphasis on its relevance to athletic populations. Insights were categorized into key areas, including the gut-brain axis, energy metabolism, and the impact on mental resilience.

This methodology ensures a comprehensive evaluation of the ketogenic diet's therapeutic potential, laying the groundwork for its targeted application in treating depression among athletes.

Key outcomes from reviewed studies

The reviewed studies consistently demonstrate that the ketogenic diet (KD) exerts significant neurobiological effects relevant to depression. Key findings include:

1. **Effects on Neurotransmitters**: KD influences the balance of excitatory and inhibitory neurotransmitters, particularly glutamate and gamma-aminobutyric acid (GABA). This balance plays a crucial role in mood stabilization and emotional regulation (Ricci et al., 2020; Włodarczyk et al., 2021).
2. **Brain Energy Metabolism**: Ketone bodies, such as beta-hydroxybutyrate, provide an efficient alternative energy source for the brain, enhancing mitochondrial function and reducing oxidative stress (Bear et al., 2020; Tidman et al., 2024).

3. **Reduction in Neuroinflammation**: KD mitigates neuroinflammatory processes by reducing pro-inflammatory cytokines and modulating the gut-brain axis. This is particularly relevant for depression, where neuroinflammation is a key pathological component (Chrysafi et al., 2024; Mrozek et al., 2023).

Table 1: Summary of Neurobiological Effects of KD on Depression

Neurobiological Aspect	**Mechanism**	**Key Studies**
Neurotransmitter Regulation	Increased GABA-to-glutamate ratio	Ricci et al., 2020; Gumus et al., 2022
Energy Metabolism	Enhanced mitochondrial function, reduced oxidative stress	Bear et al., 2020; Tidman et al., 2024
Neuroinflammation	Reduction in pro-inflammatory cytokines	Chrysafi et al., 2024; Mrozek et al., 2023

The clinical outcomes of KD on depressive symptoms and performance metrics in athletes reveal promising trends:

1. **Reduction in Depressive Symptoms**: Numerous studies have highlighted KD's efficacy in alleviating depressive symptoms. Participants across multiple clinical trials and case studies reported significant reductions in symptom severity, improved mood stabilization, and increased emotional resilience following adherence to KD (Marx et al., 2021; Garner et al., 2024). These findings suggest that the neurobiological mechanisms of KD—enhanced brain energy metabolism, modulation of neurotransmitter activity, and reduction in neuroinflammation—directly target key components of depression's pathophysiology.
2. **Performance Metrics in Athletes**: In addition to its mental health benefits, KD positively impacts performance metrics, making it particularly appealing for athletes. Research indicates that KD supports mental resilience, reduces stress, and enhances recov-

ery, which are critical factors for athletic success. Athletes adhering to KD also demonstrated improved cognitive performance, including better focus and decision-making under pressure, likely due to the stabilizing effects of ketone bodies on brain function (Valenzuela et al., 2021; Moscatelli et al., 2020). Furthermore, the anti-inflammatory properties of KD aid in physical recovery, mitigating the stress-induced decline in performance often observed in athletes under high mental and physical strain.

Table 2: Clinical Outcomes of KD in Athletes

Outcome	**Description**	**Key Studies**
Depressive Symptom Reduction	Improved mood, reduced depressive episodes	Marx et al., 2021; Garner et al., 2024
Performance Metrics	Enhanced cognitive and physical performance	Valenzuela et al., 2021; Moscatelli et al., 2020

The dual benefits of KD for depressive symptom reduction and performance enhancement underscore its potential as a strategic intervention in sports psychiatry. Athletes often face unique challenges where mental health is intertwined with physical performance. By addressing both domains, KD offers a holistic approach to enhancing overall well-being in this population. However, tailored implementation strategies are necessary to address potential barriers, such as dietary adherence, adaptation phases, and individual variability in response to KD.

Further large-scale, randomized controlled trials are required to substantiate these findings and establish evidence-based guidelines for the integration of KD into sports psychiatry practice. These future efforts will help refine KD protocols to maximize its therapeutic and performance-enhancing potential for athletes.

The gut-brain axis is increasingly recognized as a critical pathway mediating the effects of dietary interventions, including the ketogenic diet (KD), on mental health. This bidirectional communication system between the gastrointestinal tract and the central nervous system (CNS) plays a significant role in mood regulation, neuroinflammation, and overall psychological resilience. Emerging evidence indicates that KD has profound effects on the gut microbiota,

contributing to improved mental health outcomes through enhanced gut-brain axis function (Taylor et al., 2020; Martin et al., 2023).

The ketogenic diet promotes the growth of beneficial microbial strains, such as *Akkermansia muciniphila* and *Bifidobacterium spp.*, which are associated with anti-inflammatory properties and neuroprotective effects. Increased microbial diversity supports a healthier gut environment, reducing the prevalence of dysbiosis—a condition often linked to depressive symptoms. Studies show that this microbiota shift enhances the production of short-chain fatty acids (SCFAs), such as butyrate, which have direct anti-inflammatory effects and modulate CNS function (Martin et al., 2023; Taylor et al., 2020).

Table 3: Impact of KD on Gut-Brain Axis

Gut-Brain Aspect	**Effect of KD**	**Key Studies**
Microbiota Diversity	Increased beneficial microbial strains	Martin et al., 2023; Taylor et al., 2020
Intestinal Inflammation	Reduced pro-inflammatory markers in the gut	Bear et al., 2020; Włodarczyk et al., 2021
Neuroinflammation	Reduced systemic inflammation	Chrysafi et al., 2024; Mrozek et al., 2023

Chronic intestinal inflammation, marked by elevated levels of pro-inflammatory markers like lipopolysaccharides (LPS), disrupts the gut barrier and contributes to systemic inflammation. KD reduces intestinal inflammation by modulating the production of inflammatory cytokines, thereby restoring gut integrity and reducing the inflammatory load on the CNS. This mechanism is particularly relevant in depression, where heightened systemic inflammation is a core pathological feature (Bear et al., 2020; Włodarczyk et al., 2021).

The downstream effects of improved gut health include a reduction in neuroinflammation, a condition often implicated in depressive disorders. By mitigating systemic inflammatory markers and promoting anti-inflammatory pathways, KD contributes to a more stable CNS environment. This reduction in neuroinflammation correlates with improvements in mood and

emotional resilience, supporting the use of KD as an adjunctive therapy for depression (Chrysafi et al., 2024; Mrozek et al., 2023).

For athletes, whose mental health is often closely tied to physical stress and performance, the gut-brain axis presents an actionable target for therapeutic interventions. KD's ability to enhance gut microbiota diversity and reduce neuroinflammation may not only improve mood but also bolster resilience to stress, optimize recovery, and support overall well-being. These findings highlight the potential of integrating KD into comprehensive mental health care strategies for athletic populations.

The findings underscore the multifaceted benefits of KD for depression, particularly in athletes. KD's neurobiological impact addresses core pathological mechanisms of depression, while clinical outcomes reveal improvements in mood, resilience, and performance metrics. Additionally, the modulation of the gut-brain axis provides a novel pathway for mental health enhancement, further validating KD as a viable adjunctive therapy for depression in athletic populations.

Discussion

The findings from the reviewed studies highlight the ketogenic diet (KD) as a promising intervention for managing depression, particularly in athletes. This section discusses the mechanisms through which KD influences mental health, its specific suitability for athletic populations, and the limitations associated with its application.

The neurobiological effects of KD on mental health are underpinned by its ability to influence brain energy metabolism, neurotransmitter balance, and neuroinflammation. Ketone bodies, particularly beta-hydroxybutyrate, serve as an alternative energy substrate for the brain, enhancing mitochondrial efficiency and reducing oxidative stress. These mechanisms are critical in addressing the metabolic dysfunctions often observed in depression (Ricci et al., 2020; Bear et al., 2020).

Additionally, KD increases the GABA-to-glutamate ratio, contributing to mood stabilization and the reduction of excitotoxicity, which are key factors in the pathophysiology of depression (Włodarczyk et al., 2021). The modulation of the gut-brain axis further amplifies KD's

antidepressant effects by fostering a diverse and healthy gut microbiome, reducing systemic inflammation, and promoting neuroprotection (Martin et al., 2023; Chrysafi et al., 2024). These interconnected pathways establish KD as a viable intervention targeting both the physiological and psychological components of depression.

Athletes represent a unique population for KD application due to their physical and mental health demands. Depression in athletes is often linked to high-performance stress, overtraining, and injuries, which exacerbate both physiological and psychological vulnerabilities. KD offers a dual advantage by addressing these stressors through metabolic optimization and mood enhancement (Valenzuela et al., 2021; Garner et al., 2024).

The energy stability provided by ketosis is particularly beneficial for athletes, as it supports cognitive function, resilience, and recovery during training and competition. Furthermore, KD's ability to reduce neuroinflammation and oxidative stress aligns with the need for efficient recovery mechanisms in athletic contexts (Moscatelli et al., 2020; Tidman et al., 2024). However, implementing KD in this population requires careful consideration of its impact on physical performance, as low carbohydrate availability may initially impair endurance in certain disciplines (Burke, 2021).

Despite its potential, KD faces several challenges in clinical and practical application. Adherence is a significant barrier, as KD requires strict dietary compliance, which may be difficult to maintain, particularly in the context of athletes with demanding schedules and varied dietary needs (Chrysafi et al., 2024). Moreover, the potential side effects, including fatigue, gastrointestinal discomfort, and micronutrient deficiencies, need to be addressed to enhance its feasibility as a long-term intervention (Marx et al., 2021).

The current body of research is limited by a lack of large-scale, randomized controlled trials focusing specifically on athletic populations. While preclinical and clinical studies provide valuable insights, more targeted research is needed to elucidate the optimal protocols for implementing KD in athletes, including its long-term effects on mental health and performance metrics (Bear et al., 2020; Tidman et al., 2022).

Conclusions

The ketogenic diet (KD) represents a promising dietary intervention for managing depression in athletes, offering unique benefits through its multifaceted neurobiological effects. By enhancing brain energy metabolism, stabilizing neurotransmitter activity, and reducing neuroinflammation, KD directly addresses key mechanisms underlying depression. Furthermore, its ability to modulate the gut-brain axis introduces an additional pathway through which dietary changes can improve mental health outcomes.

For athletes, who are particularly susceptible to depression due to performance pressures, physical stress, and injury-related challenges, KD provides a dual advantage. Beyond mood stabilization, KD's role in supporting cognitive function, resilience, and recovery enhances its relevance to this population. The reviewed evidence underscores its potential as an adjunctive therapy, particularly for individuals seeking alternative or complementary approaches to conventional treatments.

However, the application of KD in both clinical and athletic contexts is not without limitations. Adherence to the diet, potential side effects, and the risk of impairing physical performance during adaptation periods must be carefully managed. Additionally, the current literature is constrained by a lack of robust, large-scale randomized controlled trials that specifically investigate the long-term effects of KD on depression in athletes. These gaps highlight the need for further research to validate its efficacy and optimize its implementation.

In conclusion, KD emerges as a compelling dietary strategy with significant potential for improving mental health in athletes. Future studies should prioritize the development of tailored KD protocols, address barriers to adherence, and explore its integration into holistic mental health care frameworks. With such advancements, KD may become a valuable tool in the prevention and management of depression in athletic populations.

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