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Review Article

The Contribution of Ketogenic Diets Combined with Physical Activity to the Increase of BDNF and GH in Neuroplasticity in Animals

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Abstract

This article reviews the contribution of ketogenic diets combined with physical activity in increasing levels of Brain-Derived Neurotrophic Factor (BDNF) and Growth Hormone (GH) in neuroplasticity in animals. Neuroplasticity is crucial for the adaptation and functional recovery of the nervous system, and nutritional approaches have shown promise in this context. The ketogenic diet, characterized by high lipid intake and low carbohydrates, induces the production of ketone bodies, which act as epigenetic modulators and neuroprotectors. Studies demonstrate that this diet, combined with physical exercise, can increase levels of BDNF and GH, promoting neurogenesis and synaptogenesis, as well as improving cognition and emotional well-being in animals, particularly in the elderly and epileptic populations. The review also highlights the inadequacy of commercial pet foods, which often contain high levels of carbohydrates, negatively impacting animal health. Scientific literature suggests the need for reformulating these diets to better meet the nutritional needs of dogs and cats. The combination of ketogenic diet and physical activity offers significant potential for clinical interventions in veterinary medicine, promoting neurological health and quality of life in animals. This article emphasizes the importance of further research to validate these findings and establish practical guidelines for implementing these nutritional strategies in veterinary practice.

Keywords

Ketogenic Diet, Neuroplasticity, Brain-derived Neurotrophic Factor (BDNF), Growth Hormone (GH)

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1. Introduction

Neuroplasticity, defined as the ability of the nervous system to modify itself in response to internal and external stimuli, is a vital phenomenon for recovery and functional adaptation in various animal species. This remarkable capacity allows organisms to adjust their neural pathways and synaptic connections, enabling them to learn from experiences, recover from injuries, and adapt to changing environments. Understanding neuroplasticity has profound implications not only for neuroscience but also for veterinary medicine, as it offers insights into how animals can maintain cognitive and behavioral health throughout their lives [1].

Recently, nutritional and behavioral strategies, such as the ketogenic diet combined with physical activity, have shown a significant role in modulating neurotrophic factors, especially Brain-Derived Neurotrophic Factor (BDNF) and Growth Hormone (GH). These factors are crucial for the development, maintenance, and plasticity of neurons, influencing cognitive functions such as memory, learning, and emotional regulation. According to Kamondouza [1], these approaches can promote substantial improvements in cognition, learning, mood, and neurological adaptation, expanding the therapeutic horizon in Veterinary Medicine.

The ketogenic diet, characterized by high lipid intake and carbohydrate restriction, stimulates the production of ketone bodies, such as β-hydroxybutyrate, which acts as an epigenetic modulator and neuroprotector. This metabolic shift not only provides an alternative energy source for the brain but also influences gene expression related to neuronal health. When combined with regular physical exercise, this metabolic pattern triggers increased levels of BDNF and GH, enhancing neurogenesis, synaptogenesis, and resistance to oxidative stress [2]. The synergistic effects of these two interventions can significantly bolster cognitive resilience, particularly in aging animals.

Recent studies demonstrate that the interaction between diet and physical activity can have synergistic effects that go beyond the simple sum of their benefits, promoting a neuroprotective environment that favors brain health [3, 4]. This interaction highlights the importance of a holistic approach to animal health, where dietary choices and physical activity are integrated into a comprehensive wellness strategy. The potential for such strategies to mitigate the risks of neurodegenerative diseases is particularly relevant in the context of an aging pet population, where cognitive decline is a growing concern.

Studies such as Dr. Sten Ekberg's [5] in the United States reinforce this evidence, especially in the context of controlling neurodegenerative diseases and improving the quality of life in senior animals. His research underscores the importance of proactive interventions in veterinary care, suggesting that dietary modifications and increased physical activity can lead to significant enhancements in cognitive function and overall well-being. This work proposes a detailed scientific review of the synergistic effects between ketogenesis and physical exercise on animal neuroplasticity, aiming to provide solid evidence for future veterinary clinical interventions.

Furthermore, recent research has questioned the composition of commercial pet foods, particularly regarding the high carbohydrate content, which may be inadequate for dogs and even more so for cats, which are strict carnivores. Many commercial diets fail to meet the specific nutritional needs of these animals, potentially contributing to a range of health issues, including obesity, diabetes, and cognitive decline. This nutritional incongruity raises the urgent need for reformulating these diets in light of updated scientific evidence [6-9].

The implications of these findings are profound, as they suggest that a reevaluation of dietary guidelines and the formulation of pet foods could play a critical role in enhancing the health and longevity of companion animals. By aligning pet nutrition with the latest scientific insights into neuroplasticity and metabolic health, veterinarians can better support the cognitive and emotional needs of their patients [10, 11].

In conclusion, this introduction sets the stage for a comprehensive exploration of how nutritional and behavioral strategies can enhance neuroplasticity in animals. By integrating insights from neuroscience, nutrition, and veterinary medicine, we can develop more effective interventions that promote cognitive health and improve the quality of life for pets. The subsequent sections will delve deeper into the mechanisms underlying these effects, the current state of research, and practical recommendations for veterinary practice [2, 5].

2. Literature Review

The ketogenic diet was originally developed for the control of refractory epilepsy in humans, but its benefits have also been explored in veterinary medicine. According to Freeman et al. [12], the production of ketone bodies improves mitochondrial function and reduces systemic inflammation, showing promise for neurological disorders in dogs and cats. A study conducted by Packer et al. [13] revealed that dogs with idiopathic epilepsy treated with a ketogenic diet had a significant reduction in seizure frequency, highlighting the therapeutic potential of this dietary approach.

In addition to controlling epilepsy, the ketogenic diet has been associated with improvements in cognitive health and physical performance in pets. Studies show that ketosis can increase the availability of energy for the brain, favoring cognitive processes and memory [14]. In a study conducted by Huber et al. [15], dogs on a ketogenic diet showed significant improvements in learning tests, suggesting that ketosis may act as a facilitator of neuroplasticity and cognitive function.

BDNF is a neuropeptide essential for the growth and differentiation of neurons and synapses, being closely related to memory and learning [14]. Physical activity, in turn, acts as a

potent inducer of BDNF expression, as demonstrated by Cotman and Berchtold [16], and synergizes with ketogenesis in promoting neurological health. The combination of physical exercise and a ketogenic diet not only increases BDNF levels but also improves synaptic connectivity, which is crucial for learning and memory.

GH also plays a crucial role in neural regeneration and synaptic plasticity, as indicated by studies from Liu et al. [17], highlighting its importance in nerve tissue repair in injury or aging situations. The interaction between BDNF and GH is fundamental, as both neurotrophic factors can work together to promote neuroplasticity and functional recovery after injuries. This synergy may be especially relevant in clinical contexts, where neuroprotection and functional recovery are priorities.

In veterinary practice, the introduction of metabolic strategies such as ketogenesis still faces resistance due to the lack of longitudinal data. However, recent investigations, such as those by Kamondouza [1], have reported increases in vitality and cognition in geriatric animals subjected to this dietary model. The application of ketogenic diets in clinical contexts has shown promising results, but a greater number of controlled studies are still needed to validate these findings and establish clear guidelines for veterinary practice.

Moreover, the growing popularity of ketogenic diets among pet owners raises questions about the nutritional adequacy and long-term safety of these diets. Additional research is needed to investigate the long-term effects of ketosis in different age groups and health conditions, especially in animals with comorbidities. Continuous evaluation of the composition of commercial pet foods and the search for healthier alternatives are essential to ensure the well-being of animals.

Finally, the interrelationship between diet, physical activity, and neurological health in pets is an expanding field that deserves attention. Promoting a healthy lifestyle, which includes a proper diet and regular exercise, can have a significant impact on the quality of life of animals, especially as they age. Ongoing research in this area may lead to new therapeutic approaches that integrate nutrition, exercise, and mental health into a holistic model of veterinary care.

3. Discussion

Studies indicate that commercial dry foods may contain between 30% to 60% carbohydrates, while the ancestral diet of dogs and cats presents significantly lower levels [10, 11]. This discrepancy may negatively impact the health of animals, contributing to obesity, diabetes, intestinal dysfunctions, and behavioral changes. The high carbohydrate content in many commercial diets often exceeds the natural dietary needs of these animals, leading to metabolic imbalances and associated health issues. It is crucial to understand how these dietary components affect not only physical health but also behavioral and cognitive functions.

The relationship between diet quality and mental health is a rapidly expanding field, with research suggesting that inadequate nutrition may be linked to behavioral problems in pets [18, 19]. Poor dietary choices can lead to deficiencies in essential nutrients that are vital for optimal brain function. For instance, omega-3 fatty acids, which are often lacking in commercial pet foods, play a significant role in maintaining cognitive health and emotional well-being. A diet deficient in these nutrients may predispose pets to anxiety, aggression, and other behavioral disorders.

In felines, which are strict carnivores, high carbohydrate consumption is especially harmful, as their metabolic pathway is adapted to utilize proteins and fats as primary energy sources [18]. Unlike dogs, whose digestive systems can handle a broader range of nutrients, cats have evolved to thrive on a protein-rich diet. The ingestion of excessive carbohydrates can lead to insulin resistance, obesity, and other metabolic disorders, highlighting the need for species-specific dietary formulations. This disparity in dietary requirements emphasizes the importance of tailoring nutritional strategies to meet the unique needs of different species.

In dogs, although considered facultative omnivores, there is growing concern about the quality of ingredients used in commercial diets and their chronic effects. Many commercial pet foods contain low-quality fillers and artificial additives that may not only lack nutritional value but could also contribute to long-term health issues. The cumulative effect of these poor-quality ingredients can manifest as chronic inflammation, allergies, and gastrointestinal problems, further complicating the health landscape of companion animals.

Furthermore, studies demonstrate that ketogenic diets, low in carbohydrates and high in fats, promote increased levels of BDNF and GH, which may directly contribute to the cognitive, emotional, and behavioral health of animals [2, 5]. The ketogenic diet has gained attention for its potential neuroprotective effects, particularly in aging animals and those suffering from neurological disorders. By providing an alternative energy source in the form of ketones, this diet supports brain health and enhances neuroplasticity, which is crucial for learning and memory.

This approach may be particularly beneficial for geriatric patients, epileptic animals, and those with age-related cognitive decline. Older animals often experience a decline in cognitive function, and dietary interventions that enhance neurotrophic factors like BDNF can help mitigate these effects. Additionally, the anti-inflammatory properties of a ketogenic diet may further protect against neurodegeneration, making it a promising strategy for maintaining cognitive health in senior pets.

Several articles corroborate the recent evidence in our review on how physical exercise affects cognitive function, highlighting underlying mechanisms such as increased BDNF expression and improved synaptic connectivity. Regular physical activity has been shown to stimulate the production of neurotrophic factors, which support the growth and maintenance of neurons. The interaction between physical activity

and diet is emphasized as crucial for optimizing mental and cognitive health [20, 21]. This synergy suggests that a holistic approach, combining proper nutrition with regular exercise, can significantly enhance the overall well-being of pets.

There is also evidence that excess carbohydrates and conventional proteins in pet foods may be related to allergic and dermatological processes, such as atopic dermatitis, which has motivated the formulation of diets with unique and specific proteins [22, 23]. Allergies and skin conditions can severely impact an animal's quality of life, leading to discomfort and behavioral issues. By addressing the underlying dietary causes of these conditions, veterinarians can improve not only the physical health of pets but also their emotional well-being.

Thus, it is possible to speculate that reducing carbohydrates and individualizing protein sources may also modulate the expression of neurotrophins such as BDNF. Tailoring diets to include high-quality protein sources and reducing carbohydrate content could promote better neurological health, enhancing cognitive function and emotional stability in pets. This approach aligns with the growing recognition of the importance of nutrition in veterinary care, advocating for personalized dietary strategies that cater to the specific needs of individual animals.

Therefore, it becomes essential to promote scientific studies that evaluate the impact of commercial food composition on the neurological health of animals. Research in this area can help clarify the relationships between diet, behavior, and cognitive function, providing valuable insights for veterinarians and pet owners alike. As our understanding of these connections deepens, we can develop more effective dietary recommendations that prioritize the health and well-being of companion animals.

The correlation between ketogenesis, physical activity, nutritional quality, and animal welfare paves the way for developing new dietary guidelines capable of promoting the overall health of small animals. By integrating insights from nutrition, exercise, and behavioral science, veterinary professionals can create comprehensive care plans that enhance the quality of life for pets. This multidisciplinary approach not only addresses existing health issues but also promotes preventive care strategies that can help maintain optimal health throughout an animal's life.

In conclusion, the implications of diet on the health and behavior of companion animals are profound and warrant further exploration. As we continue to uncover the intricate relationships between nutrition, neuroplasticity, and overall well-being, it is imperative that veterinary practices adapt to incorporate these findings into their care protocols. By prioritizing high-quality, species-appropriate diets and encouraging regular physical activity, we can significantly improve the health outcomes and quality of life for our beloved pets.

4. Final Considerations

This study explores how dietary interventions can impact the management of neurodegenerative diseases, emphasizing the importance of adequate nutrition for brain health. The inclusion of specific diets, such as the ketogenic diet, can be discussed regarding its effectiveness in improving cognitive function and slowing disease progression.

The ketogenic diet, combined with regular physical exercise, shows promising effects in stimulating neurotrophins such as BDNF and GH, contributing to neuroplasticity and well-being in animals, especially seniors. The adoption of this nutritional protocol requires careful monitoring and individualized assessment but represents a potential advance in the management of neurological diseases and healthy aging. The implementation of multidisciplinary strategies in veterinary clinics could make this model more accessible, integrating nutrition, neurology, and behavior in favor of animal health.

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Abbreviations

BDNF	Brain-Derived Neurotrophic Factor
GH	Growth Hormone

Author Contributions

Daniel Checchinato: Methodology, Visualization, Writing – review & editing

Claudio Amichetti Jr: Conceptualization, Data curation, Investigation, Resources, Writing – original draft

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Camila Olveira Costa Ferreira de Carvalho: Conceptualization, Investigation, Resources

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Conflicts of Interest

The authors declare no conflicts of interest.

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