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A Focused Approach on the Expected Effects of the Ketogenic Diet on Health and Sports Performance

مقاربة متمحورة حول التأثيرات المتوقعة للنظام الكيتوني على الصحة والفورمة الرياضية

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Abstract

This study aims to analyze the effect of the ketogenic diet on general health and sports performance, which are among the most important goals pursued by athletes. Amid the proliferation of dietary systems with their respective benefits and drawbacks, and the studies that either support or contradict them, there has been an increasing spread of this dietary pattern in recent years — whether through its practical adoption by individuals, its promotion, or the large volume of research conducted on it, particularly in the areas of weight loss and general health improvement. However, this common use does not reflect the original therapeutic purpose of the ketogenic diet. Recent literature has seen a notable growth in studies addressing its various applications, including its effects on sports performance and the physical level of athletes. Findings indicate that athletes' performance responses to this diet are not uniform, varying according to multiple factors such as individual physical and physiological characteristics and the nature of the sport practiced. Accordingly, this study seeks to present a conceptual framework for the ketogenic diet, review its most notable applications, and shed light on its potential effects on certain physical capacities related to athletic performance.

الكلمات المفتاحية:

النظام الكيتوني

الصحة

التغذية الرياضية

الفورمة الرياضية.

ملخص

تهدف هذه الدراسة إلى تحليل تأثير النظام الغذائي الكيتوني على الصحة العامة الفورمة الرياضية التي تعد من اهم ما يسعى اليه الفرد الرياضي، في ظل تعدد الأنظمة الغذائية وإيجابيات وسلبيات كل نوع منها وكذا الدراسات التي تؤيدها والتي تتعارض معها ،الا ان هناك انتشار متزايد لهذا النمط الغذائي خلال السنوات الأخيرة سواء من خلال تنفيذه من طرف الافراد من خلال الدعاية له او من خلال الكم الكبير للدراسات التي اجرية حوله ، لا سيما في مجالات فقدان الوزن وتحسين الصحة العامة. غير أن هذا الاستخدام الشائع لا يعكس الأصل العلاجي للنظام الكيتوني، حيث شهدت الأدبيات الحديثة تنامياً ملحوظاً في الدراسات التي تناولت تطبيقاته المختلفة، بما في ذلك تأثيره على الفورمة الرياضية والمستوى البدني للرياضيين. وتشير النتائج إلى أن استجابة آداء الرياضيين لهذا النظام ليست موحدة فيما بينهم نظرا لعديد العوامل، حيث تتباين تبعاً لخصائص الفرد البدنية والتكوينية الفسيولوجية وطبيعة النشاط الرياضي الممارس من طرف الفرد .وعليه، تسعى هذه الدراسة إلى تقديم إطار مفاهيمي للنظام الغذائي الكيتوني، واستعراض أبرز استخداماته، مع تسليط الضوء على تأثيراته المحتملة على بعض القدرات البدنية المرتبطة بالأداء الرياضي.

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1. Introduction

Dietary systems are among the most important components of athletic performance, as they ensure that the athlete maintains a high level of performance by providing the necessary nutritional components. Weineck (1997) notes that high athletic performance can only be achieved through optimal training and an optimal dietary regimen, which maintains five energy balances: caloric balance, macronutrient balance, mineral balance, vitamin balance, and fluid balance.

On this basis, athletes follow specific dietary patterns according to the type and nature of the sport they practice. This dietary system is also influenced by the nature of training, the structured program during the training period, and its position relative to competition. Endurance sports such as marathons and cycling differ from weight-based sports such as boxing and weightlifting, and also differ from swimming and team sports, and may even vary within the same sport. Preparatory periods differ from competition periods and transitional recovery phases. All these variables are taken into account when planning a specific dietary pattern for athletes.

There are many dietary programs and systems, each with its own benefits and drawbacks. Among these is the ketogenic diet, known by various names such as keto diet, ketogenic diet, or Ketogenic Diet. It is a low-carbohydrate, high-fat dietary system, very similar to the Atkins Diet. This diet relies on limiting carbohydrate intake while increasing fat consumption, which causes the body to enter a metabolic state called ketosis. This directs the body to burn fat for energy by converting fats into ketones in the liver, which the brain can use as an energy source. Ketogenic meals can cause a significant reduction in blood sugar and insulin levels, which plays a role in stimulating increased ketone levels in the blood (Mina, 2020). The KD is most commonly used to treat metabolic disorders, obesity, cardiovascular diseases, and type 2 diabetes. Skeletal muscles constitute 40% of total body mass and are one of the primary sites for glucose disposal (Paoli et al., 2019). Athletes are increasingly adopting low-carbohydrate, high-fat, and ketogenic diets for body composition and performance improvement. However, there is currently no consensus on their effectiveness in improving performance, nor is there comprehensive literature on athletes' experiences while following this dietary regimen (Zinn et al., 2017).

Based on the above, the main research question is: What is the effect of the ketogenic diet on athletes' performance?

2. Research Objectives

- To understand the concept of the ketogenic diet, its types, and its most important nutritional components.

- To understand the benefits of the ketogenic diet and its side effects.

- To understand the physiological mechanism of the ketogenic diet (ketosis).

- To understand the most important benefits and studies addressing sports and the ketogenic diet.

3.Research Significance

The significance of this research lies in its focus on one of the dietary systems that has become increasingly used in recent times, despite its historical origins. It has proven its worth in treating certain diseases and alleviating others, in addition to weight reduction. Our contribution lies in presenting the benefits of its use for athletes — particularly elite-level athletes — in terms of its most important advantages, as well as the precautions that coaches should take when adopting it, through the presentation of selected studies and their key findings.

4. Conceptual Framework of the Ketogenic Diet

4.1 Definition

The ketogenic diet is a high-fat, low-carbohydrate, and moderately protein dietary regimen that has been used since 1924 for drug-resistant epilepsy in children. Its effectiveness and safety have been demonstrated in numerous studies over the past decade. Although it was initially established in the United States, its recent resurgence has led to its expanded use in most major

academic medical centers (Kossoff & McGrogan, 2005). In simplified terms, it involves a change in the proportions of food components: fats increase to reach 75% of calories, followed by protein at a good ratio (20%), while carbohydrates are drastically reduced to only 5% of total calories. The amount of fat in a meal may reach three to four times the combined amount of protein and carbohydrates, at which point what are known as ketone bodies are formed, playing an active role in altering the neurological and chemical activity of the body (Salama, 2016).

4.2 Types of the Ketogenic Diet

-Standard Ketogenic Diet (SKD): A low-carbohydrate, moderate-protein, and high-fat diet. It typically contains 70% fat, 20% protein, and only 10% carbohydrates.

- Cyclical Ketogenic Diet (CKD): This diet involves periods of high-carbohydrate refeeding, such as 5 ketogenic days followed by 2 high-carbohydrate days.

- Targeted Ketogenic Diet (TKD): This allows adding carbohydrates around workouts.

- High-Protein Ketogenic Diet: Similar to the standard ketogenic diet but contains more protein. The typical ratio is 60% fat, 35% protein, 5% carbohydrates (Mawer, 2020).

It must be noted that there are other variants, such as the Low-Carbohydrate Ketogenic Diet (LDK) and the Very Low-Carbohydrate Diet (ULDK).

4.3 Allowed and Avoided Foods

Allowed foods: Full-fat dairy products (butter, cream, cheese, yogurt), eggs, oils (olive, coconut, avocado), avocado, nuts (almonds, walnuts, hazelnuts), seeds (chia, sesame, pumpkin), fish and seafood (salmon, tuna, mackerel, oysters, mussels, squid), red meat and chicken (fatty cuts), low-starch vegetables (tomatoes, onions, peppers, cauliflower, mushrooms, leafy greens), and berries (blueberries, blackberries, strawberries).

Foods to avoid or limit: Fruits (except berries), root and tuberous vegetables (potatoes, carrots, parsnips), legumes and beans (chickpeas, dried beans, black beans, lentils, peas), grain products (bread, rice, pasta, breakfast cereals), sugary or sweetened foods and drinks (candy, cakes, ice cream, soft drinks, artificial sweeteners, sweetened sauces), refined or processed oils (vegetable oil, sunflower, sesame, corn), and low-fat processed products (Cleveland Clinic, 2018).

5. Health Benefits and Side Effects

5.1 Health Benefits

- Appetite regulation: One of the first things people notice when in ketosis is that they do not feel as hungry. Research has shown that being in ketosis suppresses appetite and reduces levels of ghrelin, known as the 'hunger hormone.'

- Diabetes and prediabetes: In people with type 2 diabetes or prediabetes, being in ketosis can help regulate blood sugar and insulin response, potentially reducing the need for diabetes medication.

- Epilepsy: Maintaining ketosis with a classic keto diet or the less strict Modified Atkins Diet (MAD) has proven effective in controlling epilepsy in both children and adults who do not respond to antiepileptic drugs (Spritzler, 2020).

- Heart disease: The ketogenic diet can help improve risk factors such as body fat, HDL (good) cholesterol levels, blood pressure, and blood sugar.

- Cancer: It is currently being explored as an adjunct cancer treatment as it may help slow tumor growth.

- Alzheimer's disease: The keto diet may help reduce symptoms and slow the progression of Alzheimer's disease.

- Parkinson's disease: One study found that the diet helped improve Parkinson's symptoms.

5.1.1 Supporting Study — Autism

A pilot study by researcher Athanasios Evangeliou examined the role of the ketogenic diet on 30 children aged 4 to 10 years with autistic behavior. The diet was applied for 6 months, in 4-week continuous cycles with 2-week diet-free intervals. Eighteen out of 30 children (60%) adhered to the diet. Two (02) out of 30 patients showed significant improvement, while

six (06) showed moderate improvement, indicating that 26.66% of patients benefited considerably. The diet proved effective in reducing various generalized behaviors, allowing patients to focus better and increasing their learning capacities. Children with significant improvement stopped medication, and two were able to attend regular school. Notably, the beneficial effects of the keto diet persisted during diet-free periods (Evangeliou, 2003).

5.1.2 Effect on Obesity

The ketogenic diet affects body weight. Paoli (2014) describes the mechanisms through which the KD contributes to weight loss:

- Decreased appetite due to the high satiety effect of proteins, effects on appetite-regulating hormones, and a possible direct appetite-suppressing action of ketone bodies.

- Reduced lipogenesis and increased lipolysis.

- Increased metabolic efficiency in fat consumption, notably reflected in a reduced resting respiratory rate.

- Increased metabolic costs of gluconeogenesis and the thermogenic effect of proteins.

- A low-carbohydrate dietary period may help control hunger and improve oxidative fat metabolism, thus reducing body weight.

- New types of ketogenic diets using meals that mimic carbohydrate-rich foods can improve dietary compliance.

The duration of the ketogenic diet may range from a minimum of 2 to 3 weeks (to induce physiological ketosis) to a maximum of several months (6–12 months). A proper understanding of the ketogenic diet can make it a useful tool for treating obesity under medical supervision (Paoli, 2014).

5.2 Side Effects and How to Minimize Them

Although the ketogenic diet is safe for healthy individuals, there may be some initial side effects while the body adapts to it. This condition is often referred to as 'keto flu' and typically occurs within a few days (Daily Medical Information, 2020).

- Keto flu: At the start of the keto diet, most people experience flu-like symptoms including headaches, fatigue, irritability, constipation, nausea, vomiting, dizziness, and muscle pain. The body produces ketones and eliminates them through frequent urination, which can lead to electrolyte loss and dehydration, contributing to flu-like symptoms lasting approximately one week.

- Diarrhea: This may occur due to inadequate fiber replacement or gallbladder overload from increased fat digestion.

- Ketoacidosis: Individuals with type 1 or type 2 diabetes must not follow the keto diet without medical consultation, as it may lead to dangerous diabetic ketoacidosis, potentially causing liver, kidney, and brain damage if untreated.

- Weight regain: The keto diet is highly restrictive and not suitable for long-term adherence. Most people regain much of the lost weight upon returning to their regular diet.

- Decreased muscle mass and metabolic rate: Weight changes may also result from muscle mass loss, particularly when fat intake greatly exceeds protein intake, negatively affecting metabolism and resting metabolic rate in the long term.

- Increased risk of cardiovascular and kidney diseases: Frequent urination leads to loss of electrolytes (sodium, magnesium, potassium), increasing the risk of acute kidney failure, cardiac arrhythmias, kidney stones, and dehydration. A study presented at the European Society of Cardiology found that people consuming low-carbohydrate meals have an increased risk of death from cancer and cardiovascular disease.

- Nutritional concerns: The keto diet is low in fruits, vegetables, whole grains, and legumes, leading to potential loss of fiber, vitamins, minerals, and phytochemicals, with possible long-term effects such as osteoporosis and increased risk of chronic diseases.

Campos (2020) notes that a main criticism of this diet is that many people tend to consume too much protein and poor-quality fats from processed foods, with very little fruits and vegetables. Kidney patients

need to exercise caution as this diet may worsen their condition.

6. Ketone Bodies and the Phenomenon of Ketosis

6.1 Ketosis

Ketosis is a metabolic state in which the body uses fat as fuel instead of carbohydrates. Modifying one's diet and practicing intermittent fasting can help enter ketosis more quickly. Certain tests and symptoms can also help determine whether one has entered this metabolic state (Mawer, 2020).

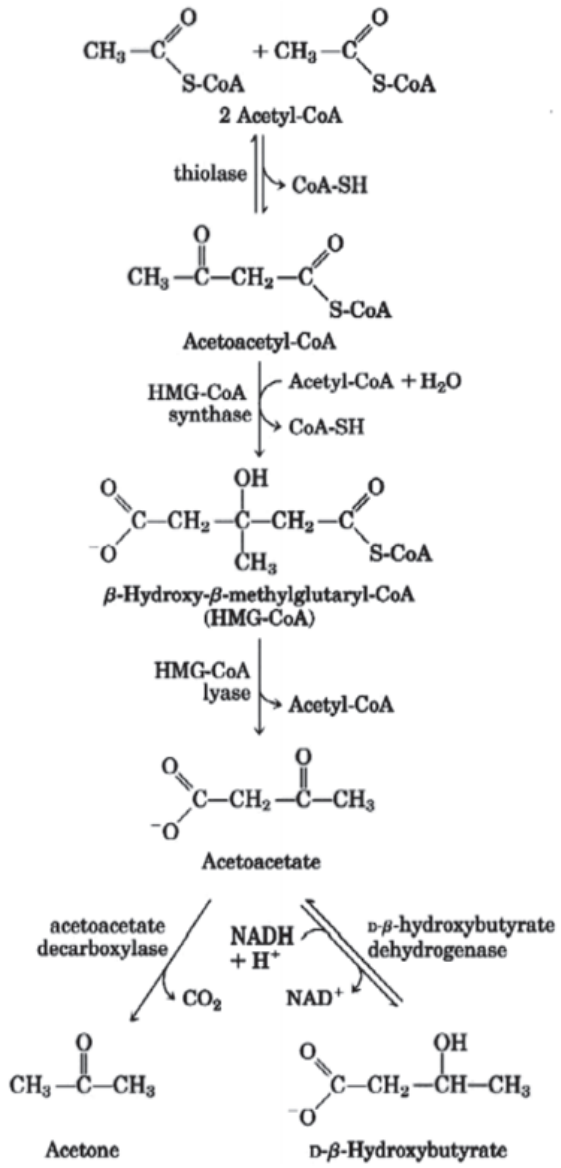
6.2 Ketone Bodies

Ketone bodies are three water-soluble molecules — acetoacetate, beta-hydroxybutyrate, and acetone — synthesized by the liver from fatty acids. This occurs during periods of low food intake (fasting), low-carbohydrate diets, starvation, or prolonged intense exercise, as well as in individuals with untreated type 1 diabetes. These ketone bodies are rapidly taken up by extra-hepatic tissues and converted into acetyl-CoA, which enters the citric acid cycle and is oxidized in mitochondria to produce energy. In the brain, they are used to synthesize long-chain fatty acids that cannot cross the blood-brain barrier. In this way, during hypoglycemia, the brain can use 40 grams of glucose per day instead of the normal 120 grams, deriving most of its energy from ketone bodies (Wikipedia, 2020).

Paoli (2014) explains that after a few days of fasting or following a very low-carbohydrate diet (less than 20 grams per day), the body's glucose reserves become insufficient to produce oxaloacetate for normal fat oxidation in the Krebs cycle and to supply the central nervous system (CNS) with glucose. Since the CNS cannot use fatty acids as an energy source, after 3–4 days it requires an alternative energy source derived from excess acetyl-CoA, leading to the production of ketone bodies: acetoacetate (AcAc), β-hydroxybutyric acid (BHB), and acetone. Ketogenesis occurs mainly in the mitochondrial matrix of the liver. The liver produces ketone bodies but cannot utilize them due to the absence of the enzyme required to convert acetoacetate into acetoacetyl-CoA (Paoli, 2014).

Figure 1

Pathway of ketone body formation from acetyl-CoA



Source: (Paoli, 2014)

6.3 Ketone Body Utilization

Ketone bodies can be utilized by the body's cells to produce the energy they require. They are transported from the liver to other tissues, where acetoacetate (AcAc) and beta-hydroxybutyrate (BHB) can be reconverted into acetyl-CoA to generate energy through the citric acid cycle (Krebs cycle). However, ketone bodies cannot be utilized by the liver itself for energy because the liver lacks the enzyme **thiophorase** (succinyl-CoA:3-ketoacid CoA transferase).

At low concentrations, acetone is taken up by the liver to undergo detoxification via the methylglyoxal pathway, which culminates in the production of lactic

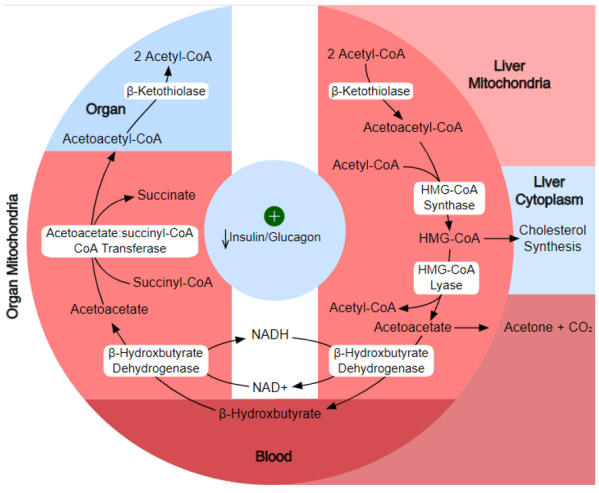
acid. In high concentrations resulting from prolonged fasting or a ketogenic diet, acetone is absorbed by extrahepatic cells and enters a different pathway through 1,2-propanediol. Although this pathway involves a distinct sequence of steps requiring adenosine triphosphate (ATP), 1,2-propanediol can eventually be converted into pyruvic acid.

Under normal physiological conditions, the heart preferentially utilizes fatty acids for fuel; however, under conditions of hyperketonemia (elevated blood ketones), the heart effectively utilizes ketone bodies for energy. Similarly, the brain derives a portion of its energy from ketone bodies when glucose availability is reduced, such as during fasting, starvation, carbohydrate-restricted diets, ketogenic diets, or intense physical exercise.

When blood glucose levels are low, extrahepatic tissues have access to auxiliary energy sources in addition to ketone bodies, such as fatty acids. Nevertheless, the brain maintains an obligatory requirement for a baseline level of glucose. After three days of a low-glucose diet, the brain obtains approximately 25% of its energy from ketone bodies. After roughly four days, this ratio increases to 70%. In the initial stages of adaptation, the brain does not oxidize ketone bodies as fuel because they serve as essential substrates for cerebral lipid synthesis. Furthermore, ketone bodies derived from omega-3 fatty acids may mitigate the decline of cognitive abilities in later life (Wikipedia, 2020).

Figure 2

The biochemical pathway of ketogenesis in the liver and utilization by organs.



Source:(Christensen, 2018)

7. Ketogenic Diet in Sports

Studies differ on the effect of the ketogenic diet on the athlete's body and performance level, and this also varies from one sport to another. There is no consensus on the effectiveness of the ketogenic diet for athletic performance (Zinn et al., 2017). Below, we review selected studies addressing the effect of the ketogenic diet on athletes.

7.1 Effect on Muscle Mass

- Rapid weight loss should generally be avoided. Long-term planning and gradual body weight reduction are recommended. The ketogenic diet may be viable, but a minimum of 2 weeks is necessary to avoid negative effects on performance, particularly in aesthetic sports such as bodybuilding.

- Using the ketogenic diet during bodybuilding 'mass gain' phases is not beneficial, as all biochemical and molecular data indicate it is very difficult to increase muscle mass while following this diet. Its use should therefore be limited to the few days immediately preceding bodybuilding competition (Paoli et al., 2015).

- The overall effect appears to consist of preserving muscle mass rather than achieving net hypertrophy (Paoli et al., 2019).

Literature suggests several mechanisms through which a ketogenic diet (KD) may support muscle growth:Enhanced Fat Oxidation and Energy Utilization: Ketosis improves the body's capacity for lipid oxidation, providing a sustainable energy source that may support muscle growth and recovery. Furthermore, this metabolic state aids in "glycogen sparing," allowing athletes to maintain energy levels during prolonged training sessions.Reduced Inflammation and Improved Recovery: Research indicates that a ketogenic diet lowers systemic inflammation levels, a critical factor for rapid muscle tissue repair and regeneration between workouts. Additionally, it may enhance mitochondrial function, thereby boosting the muscles' hypertrophic capacity. Hormonal Balance: The ketogenic diet can improve insulin sensitivity, allowing for more efficient nutrient partitioning. Studies also suggest it may

stimulate the production of Growth Hormone (GH) and Testosterone, both of which play vital roles in muscle synthesis and repair.Muscle Protein Synthesis (MPS) and Maintenance: Consuming a moderate protein intake ($1.2–1.7$ g/kg of body weight) can promote muscle growth without compromising the state of ketosis. It has been found that this regimen helps preserve lean body mass (LBM) during weight loss, while achieving gains in strength and mass comparable to non-ketogenic diets when combined with resistance training.Challenges and Critical ConsiderationsDespite the potential benefits, several factors must be considered:Keto-adaptation Period: Individuals may experience a temporary decline in energy levels and training intensity initially. This phase can last from a few days to several weeks until the body fully adapts to utilizing ketones as its primary fuel source.Performance in High-Intensity Sports: Evidence remains limited regarding the efficacy of keto in sports requiring explosive power (e.g., sprinting or maximal weightlifting), as these activities rely primarily on glycolytic pathways (carbohydrates).Adherence and Protein Quality: The restrictive nature of the diet may pose challenges for long-term adherence. Furthermore, ensuring high-quality protein sources and a balanced profile of Essential Amino Acids (EAAs)—particularly Leucine—is crucial to sustain the anabolic process (Tzenios & all,2023).

7.2 Effect on Explosive Strength

In a study by Paoli et al. investigating the effect of a Very Low-Calorie Ketogenic Diet (VLCKD) on explosive strength performance in 8 elite artistic gymnasts, body composition and various performance aspects were analyzed before and after 30 days of a modified ketogenic diet. The diet relied on green vegetables, olive oil, fish, and meat, supplemented with high-quality, nearly carbohydrate-free protein dishes. Key findings:

- There were no significant differences between the VLCKD and the normal diet in any strength tests.

- Differences were found in body weight and composition, with a decrease in body weight and fat mass.

- There were no differences in muscle mass (Paoli et al., 2012).

7.3 Ketogenic Diet in Weight-Class Sports

Weight-class sports often require athletes to transiently reduce body weight to compete within a specific category. The energy restriction and rapid weight loss strategies used by athletes are often ineffective and associated with negative side effects. Greene et al. suggest that coaches and athletes should consider using a Low-Carbohydrate Ketogenic Diet (LCKD) to achieve targeted weight loss goals, considering it a viable alternative strategy applicable to weightlifting and combat sports, while acknowledging that this needs further exploration in future studies (Greene et al., 2018).

Paoli et al. indicate that athletes who underwent VLCKD with adequate protein intake:

- Lost weight and improved body composition without any adverse changes in strength and power performance.

- A properly programmed and monitored ketogenic diet can be a useful and safe method to help athletes reach desired weight categories. This diet may also be beneficial in the short term for sports involving weight categories (Paoli et al., 2012).

7.4 Effect on Endurance Performance

Numerous studies have addressed endurance performance and the ketogenic diet. Most findings indicate:

- The prevailing nutritional philosophy for endurance athletes focuses on a carbohydrate-dominant, low-fat model. Under these dietary conditions, athletes use carbohydrates as their predominant fuel source to sustain large volumes of aerobic exercise (Zinn et al., 2017).

- Long-term high-fat diets may be appropriate for aerobic endurance athletes during the preparatory season, when large training volumes are performed at low-to-moderate intensities.

- High training volume combined with the ketogenic diet enhances fat metabolism during exercise, reduces body mass and fat content, and decreases muscle

damage following exercise (Zajac, 2014).

7.4.1 Study by Adam Zajac et al.

This study determined the effects of a long-term ketogenic diet rich in polyunsaturated fatty acids on aerobic performance and exercise metabolism in off-road cyclists. Key findings:

- The ketogenic diet induced favorable changes in body weight and composition, as well as in lipid and lipoprotein profiles.

- A significant increase in relative values of maximal oxygen uptake (VO□max) and oxygen uptake at the lactate threshold (VO□ LT), attributable to reduced body weight and fat mass and/or increased fat oxidation.

- The respiratory exchange ratio (RER) was significantly lower at rest and during certain stages of the exercise protocol after the keto diet.

- Heart rate (HR) and oxygen uptake were significantly higher at rest and during the first three stages of exercise after the keto diet.

- Creatine kinase (CK) and lactate dehydrogenase (LDH) activity were significantly lower at rest and during certain stages of the 105-minute exercise protocol after the low-carbohydrate diet.

- Changes in insulin and cortisol concentrations confirm that the glucostatic mechanism controls hormonal and metabolic responses to exercise (Zajac, 2014).

7.4.2 Study by Zinn et al.

A study on high-level endurance athletes examining the effect of a 10-week ketogenic diet found:

- All athletes increased their ability to use fat as a fuel source.

- Average body weight decreased.

- Athletes reported decreased energy levels initially, followed by a return of elevated energy levels, particularly during exercise.

- Despite reduced performance and some negative experiences, athletes were keen to continue the modified low-carbohydrate eating style due to unexpected health benefits experienced.

- The decrease in body fat can be explained by a caloric deficit, as participants reported increased satiety and a general decrease in food intake.

- Fat loss was evident with changes in skinfold thickness (Zinn et al., 2017).

8. Performance Drawbacks

• Impaired "Exercise Economy": The ketogenic diet leads to an increase in the oxygen cost required to sustain a specific speed, meaning the athlete must exert more effort to achieve the same output.

• Findings from "Supernova" Studies: Research conducted on elite race walkers showed that following a keto diet resulted in a performance decline of 3% to 6%, whereas athletes on a high-carbohydrate diet improved their performance by 4% to 5% during the same period.

• Intensity Constraints: Keto limits the capacity to work at levels near maximum oxygen uptake (VO_2max), which is crucial during the decisive moments of a race. . (Burke, & Whitfield ,2024)

9. Recovery and Adaptation Challenges:

• Suppression of Carbohydrate Enzymes: Fat adaptation leads to reduced activity in the key enzymes responsible for breaking down and utilizing glycogen (stored carbohydrates). This effect persists even if the athlete attempts to consume carbohydrates immediately before a race.

• Adherence Difficulties: Studies have noted significant variability in individual responses, with high withdrawal rates from research due to the difficulty of adhering to this regimen. (Burke, & Whitfield ,2024)

8. Conclusion

Dietary regimens are an effective means of elevating athletic performance and enabling athletes to reach high levels of output; however, they require significant commitment and health monitoring before, during, and after the dietary period. It is also essential to follow a scientifically sound approach when implementing any dietary protocol. Coaches must record every detail of changes in the athlete's psychological, physiological, and physical performance, and the coaching team

must be attentive to where the dietary regimen falls within the annual training plan and its proximity to competition, so as not to negatively affect performance during competition.

The researchers recommend that further studies — particularly at the local level — be conducted on this dietary regimen and its effects on athletes.

Conflict of Interest

The authors declare that they have no conflict of interest

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