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Impact of Alternative Diets on Athletes: Analyzing Influence on Athletic Performance

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Abstract:
Diet plays a significant role in athletes' lives due to its impact on both their performance and health. Gaining a deeper insight into how diet affects athletic outcomes is crucial for designing nutritional strategies that meet the unique demands and goals of each athlete. While a variety of studies have examined different aspects of sports nutrition, there is still a clear need for further investigation in this field. This review examines the effects of alternative dietary approaches, including plant-based diets, ketogenic diets, and intermittent fasting, on athletic health and performance. Drawing on research published from 2014 to 2024, the focus is placed on experimental and systematic studies. The findings suggest that well-planned plant-based diets can deliver notable health benefits, lower the risk of chronic illnesses, and enhance aerobic capacity without hindering performance. In contrast, ketogenic diets, while potentially effective for weight loss, present concerns related to cardiovascular and bone health and may impair performance in high-intensity activities. Intermittent fasting, though showing little impact on resistance training, might negatively affect endurance performance. Overall, plant-based diets stand out as offering the most favorable combination of health advantages and performance support. To enable athletes to make well-informed dietary choices that align with their specific needs, further studies with improved methodologies are essential.

Keywords: plant-based diets, vegan, vegetarian, ketogenic diet, intermittent fasting, athletic performance, sport performance

1. Methods
The review was conducted based on studies available through the PubMed and Google Scholar databases. The studies considered for inclusion were published between 2014 and 2024, available in English, and focused on adults and athletes, regardless of gender and age. To search for relevant articles in the specified databases, the following search terms were used: "plant-based diets and athletic performance," "ketogenic diet and athletic performance," and "intermittent fasting and sports performance." A total of 29 studies were selected for the

review, of which 9 were review articles and 20 were research papers. Among the review articles, 4 focused on plant-based diets, 1 on the ketogenic diet, and the remaining 4 on intermittent fasting (IF). Of the research papers, 4 addressed plant-based diets, 9 focused on the ketogenic diet, and the remaining 4 examined IF. Exclusion criteria included case studies, opinion articles, non-English publications, studies without full-text availability, and articles not related to physical activity.

2. Introduction

Proper nutrition strategies significantly improve performance and recovery after physical activities [1].
Nutritional choices are shaped by factors such as taste, convenience, knowledge of nutritional values, and personal beliefs. For athletes, additional key factors include perceptions of diet's impact on performance, input from coaches and teammates, and the broader sports culture. Priorities may vary depending on the athlete's level of experience. Media, social norms, and pressures related to body weight and image also play a significant role in shaping dietary decisions, both among athletes and within the general population [2].
Physical endurance, particularly during extended training sessions, requires higher metabolic and nutritional support for endurance athletes [3].
Given the tough conditions they endure during their training, these athletes often turn to alternative dietary approaches to boost their performance and metabolic well-being.
This paper aims to review the literature on emerging dietary trends, including plant-based, intermittent fasting, and ketogenic diets, detailing their characteristics, risks and benefits, with a particular focus on their impact on athletic performance in sports.

3.1 Plant Based Diet

The earliest evidence of a vegetarian diet dates back to ancient times. Nowadays, vegetarian and vegan diets are gaining support worldwide, and the reasons for adopting a plant-based eating pattern vary from religious and ethical reasons to environmental concerns and health issues. The old beliefs that a plant-based diet could lead to malnutrition have been replaced by abundant evidence of health benefits, such as reducing the risk of many modern diseases [4]. Vegetarian and vegan diets are currently attracting the most attention among society [5].
A vegetarian diet is characterized by the exclusion of meat, including poultry, fish, and seafood. Vegetarianism is divided into groups based on the level of restrictions on the consumption of animal products, where ovolactovegetarians allow the consumption of dairy products and eggs, while lactovegetarians allow only milk and dairy products. A vegan and vegetarian diet differ in that a vegan diet completely eliminates animal products [6,7]. Moreover, veganism is regarded as a specific form of vegetarian diet [8].
Vegetarian diets are characterized by a high content of carbohydrates, fiber, vitamins C and E, carotenoids, omega-6 fatty acids, and folic acid, but are lower in energy, protein, omega-3 fatty acids, iron, and vitamin B12 [8,9].
Athletes following a vegan diet consume less protein compared to those on vegetarian and omnivorous diets [6,9], which is why they should pay particular attention to the quantity and quality of protein in their diet [10]. However, the position of the Academy of Nutrition and Dietetics indicates that concerns regarding insufficient protein quantity and quality in the diets of vegan and vegetarian athletes are unfounded, provided that the diet is properly designed to meet energy needs and includes a variety of plant-based protein sources [7]. The necessity of diversifying protein sources is related to the fact that plant-based proteins often lack certain essential amino acids that are more abundant in animal-based proteins, particularly branched-chain amino acids (BCAAs). These are especially crucial for physically active individuals, as they can serve as an energy source during intense exercise. Among these amino acids, leucine

plays a vital role in recovery and adaptation following physical exertion [7,11]. To ensure a complete profile of essential amino acids, it is important to combine various plant-based protein sources in the diet. Examples include beans and legumes (rich in lysine), soy and lentils (sources of leucine), as well as grains, seeds, nuts, and chickpeas (providing other essential amino acids) [7,9].

When comparing omnivorous, vegetarian, and vegan diets, vegan diets have the highest carbohydrate intake, while omnivorous diets have the lowest [12]. Carbohydrates are the main source of energy for the human body. After consumption, they are processed in a way that releases energy essential for the proper functioning of cells, especially in the brain and muscles [1]. As the duration and intensity of exercise increase, the use of carbohydrates as an energy source rises relative to other macronutrients.

Therefore, plant-based diets, characterized by high carbohydrate intake, offer benefits for endurance athletes by ensuring optimal exercise performance, maximizing glycogen resynthesis, and supporting recovery [1,12]. A carbohydrate-rich diet ensures adequate glycogen stores, and consuming carbohydrates before, during, and after exercise can improve performance in endurance sports.

Plant-based diets are rich in fiber, which is indigestible, increasing food volume and promoting early satiety. While this can be beneficial for weight loss, it may pose a challenge during training phases that require large amounts of carbohydrates. In such cases, it may be helpful to design meals with lower fiber content, opting for carbohydrate sources like rice, pasta, and buckwheat. Additionally, due to the low energy density of plant-based foods, it is advisable to consider more frequent meals and include energy-dense foods, such as nuts, seeds, and oils, to meet increased energy demands [1,9].

Vegan diets are low in saturated and total fats and high in n-6 fats, which has a positive effect on health, reducing the risk of diseases such as type 2 diabetes, heart disease and hypertension [9,10]. At the same time, veganism, due to the lack of marine-derived fats, leads to a lower intake of n-3 fatty acids (ALA, EPA, DHA), which are important for heart health, immunity and reducing inflammation. They can improve heart rate variability and nitric oxide production, which helps athletes [9]. Microalgae oil supplements and ALA-rich foods such as flaxseed, walnuts and chia seeds are good sources of DHA and EPA for vegans [7]. DHA supplementation and consumption of ALA-containing foods can improve health and performance, especially in athletes [9].

The main source of vitamin B12 in the diet are animal products, which is why vegetarians, and especially vegans who completely exclude animal products, are at risk of deficiency of this microelement if it is not supplemented or consumed in products enriched with it [7,9,13].

The prevalence of deficiency of this microelement is high among consumers of vegetarian diets, with the lowest level of consumption in the vegan population [7]. Deficiency can lead to hematological and neurological disorders such as megaloblastic anemia and neuropathy, and long-term deficiency can lead to permanent neurological damage. In relation to athletes, deficiency can lead to reduced exercise tolerance and endurance, which is why supplementation is important. Research has been conducted on the use of plant sources of this microelement, i.e. mushrooms, fermented food and seaweed, but supplement pills are still the most effective form of supplementation, despite the limited absorption of oral supplements [10].

Studies show that vegetarians and vegans who eat a diet rich in legumes and whole grains consume a similar amount of iron compared to an omnivorous diet, but the risk of iron deficiency is due to the limited bioavailability of plant-based iron [9,14]. The bioavailability of non-heme iron from plant sources depends on the body's iron status, the composition of the meal, and the presence of inhibitors (e.g., phytates) and enhancers (e.g., vitamin C). Over time, a vegetarian's body can adapt to absorb non-heme iron more efficiently, and after 10 weeks of

a low iron diet, absorption can increase by up to 40% [7]. A deficiency of this element can cause anemia, which results in symptoms such as weakness, shortness of breath and reduced exercise tolerance, but a deficiency of this element, even without anemia, causes reduced performance and makes it difficult to adapt to exercise [9]. The incidence of iron depletion is higher among vegetarians than meat eaters, with the lowest levels of iron stores found in vegans [15]. Vegan women are more susceptible to iron metabolism problems than vegan men [9]. Including vitamin C in meals supports the absorption of iron from plant sources [7,9]. In situations where iron levels are insufficient or difficult to achieve through diet alone, it is worth considering supplementing this element [9].
The amount of calcium consumed in plant-based diets depends on the restrictiveness of the diet – from higher than recommended in lacto-ovo-vegetarians to lower than recommended in vegans [7]. The data on the effect of vegetarian diets on bone mineral density and the risk of stress fractures vary depending on the source. Indicating, on the one hand, that vegetarian diets are associated with lower bone mineral density compared to omnivorous diets, with the effect of the vegan diet being more pronounced and associated with a higher risk of fractures [16,17], while other reviews indicate that bone mineral density remains within acceptable levels in both vegetarians and most vegans, confirming only that an increased risk of osteoporosis and fractures occurs in vegans with extremely low calcium intakes [12].

Benefits

The health benefits of a plant-based diet are significant and include reducing the risk of many chronic diseases such as obesity, hypertension and type 2 diabetes [7,8,11].
Demonstrated a significantly lower risk of developing or dying from ischemic heart disease and a reduced incidence of cancer. Overall analysis showed lower body mass index, lower glucose levels and better lipid profile (lower total and LDL cholesterol) among vegetarians and vegans compared to omnivores [18]. Furthermore, such diets have shown potential to reverse atherosclerosis [7,16]. This is especially important because studies suggest an increased risk of atherosclerosis and heart disease in recreational runners as they age compared to sedentary individuals. A vegetarian diet that is low in fat, when combined with other healthy habits, can help reduce plaque in the arteries. Vegetarians have a 32% lower risk of coronary heart disease than people who consume meat in their diets.
The potential benefits of plant-based diets for athletes may stem from their positive effects on body composition, blood flow, glycogen storage, and antioxidant properties, contributing to improved performance and faster recovery after exercise [16].

Risks

The main negative aspect of this type of diet is the risk of deficiencies of certain substances due to dietary restrictions. Among them, the risk of insufficient energy and protein supply and the risk of deficiencies of vitamin B12, vitamin D, iron, omega-3 fatty acids, iodine, zinc and calcium should be emphasized [6,8,9,17].
Additionally, the drawbacks of vegetarian diets for athletes stem from their plant-based nature, which includes anti-nutritional components like phytic acid, oxalates, and trypsin inhibitors. These substances hinder the absorption of certain micronutrients, reduce their bioavailability, and make the diet less digestible [17].

3.2 Ketogenic diet

People colonizing the Earth faced various climates, each completely different from the others. The population inhabiting the Arctic, where access to carbohydrates was minimal, was forced to rely on a diet primarily consisting of the meat of other animals. This meant that their diet was mainly based on proteins and fats [19].

This diet is very similar to the ketogenic diet we know, which has been studied for over 100 years. The term "ketogenic diet" first appeared in 1920, when Dr. Russell Wilder used it to treat epilepsy. Over the past 30 years, there has been a noticeable increase in scientific research, suggesting that the ketogenic diet has health benefits [20].
The ketogenic diet is based on low-carb, high-fat consumption, and its goal is to reduce body weight, increase energy, and improve mental function. People who follow this diet achieve this goal by improving metabolism and reducing body fat [21].

If we look at the ketogenic diet in terms of macronutrient intake, we will often come across a division: 10% of the diet is carbohydrates, 20% is protein, and as much as 70% is fat. These values vary depending on the sources and can be as high as: 5% of the diet based on carbohydrates, 15% of proteins and 80% of fats, within the 4:1 rule - fats to fat-free components. For the purposes of this work, the ketogenic diet is any diet with a low carbohydrate intake, i.e. <15% of the daily value of a carbohydrate-based diet, and a high fat intake, i.e. >70% of a fat-based diet [22].
Such a drastic reduction in carbohydrate intake leads to metabolic changes that alter the primary sources of energy that the human body relies on. A conventional diet relies on carbohydrates and fats as its primary sources of energy, while a ketogenic diet depletes carbohydrate stores, forcing the body to stop relying on carbohydrates as its primary source of energy and switch to fat as its primary energy source [23].
Ketosis is a metabolic state in which ketone bodies reach high concentrations in the blood (above 0.5 mM). This condition is medically referred to as hyperketonemia. When following a non ketogenic diet, the concentration of ketone bodies in the blood usually does not exceed 0.2 mM [24,25].
Under normal conditions, ketogenesis operates through a feedback mechanism. If the concentration of ketone bodies in the blood increases excessively, their synthesis will be reduced. This mechanism helps prevent ketoacidosis, a life-threatening condition (when ketone body concentration exceeds 12 mM in the blood) [25].
Although carbohydrate intake is the primary focus in most endurance sports, various nutritional strategies have been developed that are based on adaptation of the body to a ketogenic diet, allowing sparing of limited glycogen stores during physical exercise. Additionally, it was noted that the ketogenic diet, by limiting the consumption of carbohydrates, increased the production of ketone bodies, which are an additional energy component for the brain and muscle tissue [26].

Benefits
Studies on the ketogenic diet have shown that it is an important element in the treatment of epilepsy. It has been confirmed that this diet is effective in reducing epileptic seizures in children, especially in the case of treatment-resistant epilepsy. The reduction in the frequency of seizures persisted even after the ketogenic diet was discontinued [27]. Interestingly, this is not the only neurological disease in which the ketogenic diet can find its positive application. Studies on its effect on Alzheimer's disease have shown improved memory in people with the disease, as well as a reduction in the intensity of symptoms in Parkinson's disease [27,28]. Additionally, it has been proven that a high-fat diet leads to faster weight loss compared to other diets, helps control appetite, and reduces visceral obesity [28,29].

Risks
It has been proven that the ketogenic diet can have a negative impact on bone health in endurance athletes. In studies conducted on professional walkers, after 3.5 weeks of using the ketogenic diet, an increase in serological markers of bone breakdown was observed both after

exercise and at rest. Similar results were obtained in another group of professional walkers, who also showed an increase in serological markers of bone breakdown after using a low-carbohydrate diet. The concentration of these markers decreased with increasing carbohydrate consumption [30]. In addition, the ketogenic diet has also been shown to have a detrimental effect on physiological iron levels, stress levels, and inflammation in the body [31]. A study conducted by the National Birth Defects Prevention shows an increased risk of having a child with a neural tube defect, specifically spina bifida and anencephaly. Estimates of the impact of a low-carb diet have shown an 89% increased risk of neural tube defects [32]. Consumption of the ketogenic diet often leads to an increased intake of processed meat products, red meat, and saturated fats. Additionally, due to the reduction in carbohydrate intake, the consumption of fruits, vegetables, and whole grains is limited. As a result, the ketogenic diet also increases the risk of developing cardiovascular diseases, chronic kidney disease, diabetes, cancer, and Alzheimer's disease. Current literature suggests that, for most people, the risks associated with following the ketogenic diet outweigh its positive aspects [33].

3.3 Intermittent Fasting

The survival of living organisms depends on their ability to reproduce and obtain food. Depending on environmental conditions, food availability may be limited, requiring the organism to be prepared to endure periods of starvation. Through the liver and adipose tissue, the human body stores energy that can be utilized during times of reduced food accessibility. Additionally, our nervous, endocrine, and metabolic systems are evolutionarily adapted to maintain high physical and mental performance during fasting periods [34].

Intermittent fasting (IF) has been practiced since ancient times, often for religious reasons. Although food is widely available in developed countries, the topic of intermittent fasting has gained increasing popularity due to press publications and media coverage [35].

This diet can essentially be described as alternating phases of consuming food and abstaining from it. One factor contributing to the rapid surge in intermittent fasting’s popularity might be its straightforward approach. This method does not demand individuals to drastically transform their usual eating habits or replace all the items in their kitchen. Additionally, intermittent fasting does not oblige participants to exclude specific food categories or macronutrients, nor does it involve meticulously tracking calorie intake on a daily basis. These aspects significantly enhance the diet's practicality and may explain why it has gained such widespread acceptance. IF does not have strictly defined rules regarding the duration of fasting periods between meals. IF can involve limiting food intake at specific times of the day, full-day fasts, or multi-day fasts. The most commonly practiced form of IF is seen during Ramadan, when Muslims refrain from consuming food and liquids during daylight hours for an entire month [36, 37].

Non-religious fasting protocols are often based on the following principles:

- 16/8: 16 hours of fasting followed by an 8-hour eating window.
- 20/4: 20 hours of fasting followed by a 4-hour eating window.
- 5:2: A full day of fasting every other day of the week.
- Hybrids: Combining IF principles across days, such as incorporating a full-day fast every other day while following IF protocols on other days [38].

	Day 1	Day 2	Day 3	Day 4	Day 5
Whole-day fast	up to will	up to will	24h fast	up to will	up to will
Time-restricted feeding	4-8 hours of feeding / 20-16 hours fast	4-8 hours of feeding / 20-16 hours fast	4-8 hours of feeding / 20-16 hours fast	4-8 hours of feeding / 20-16 hours fast	4-8 hours of feeding / 20-16 hours fast
Alternate day fasting	up to will	24 hour fast or 25% of calorie intake	up to will	24 hour fast or 25% of calorie intake	up to will

Table 1. Difference between fasting protocoles

Intermittent fasting (IF) triggers a series of metabolic changes associated with fasting periods. Once glucose stores are exhausted, the body begins to utilize fatty acids and ketones as primary energy sources. The reduction in glucose levels during fasting inhibits glycolysis, depletes glycogen stores, and activates gluconeogenesis in the liver, during which fats are utilized. After a meal, the body undergoes another metabolic switch, this time from ketones back to glucose. Blood levels of IGF-1 and insulin decrease during fasting periods [39,40].

Benefits

Intermittent fasting has a positive impact on weight reduction. Scientific publications report weight loss ranging from 1.3% to 84% of initial body weight, while simultaneously improving metabolic health. Weight reduction achieved through this dietary approach is associated with numerous health benefits [41].

Risks

Intermittent fasting (IF) is not recommended for individuals with diabetes due to the high risk of hypoglycemia. Additionally, IF can lead to symptoms such as weakness, headaches and difficulties with concentration. Preliminary discussions have emerged about a significant increase in the risk of cardiovascular diseases associated with IF, which stated that using IF may be related to a 91% increased risk of cardiovascular death [36, 42, 43]. The impact of IF on the cardiovascular system warrants extensive investigation, as earlier studies suggested that IF was not only safe but also beneficial for this system. Regardless of its effects on weight reduction, authors agree that intermittent fasting is an effective method for lowering both systolic and diastolic blood pressure [44]. Furthermore, IF is not recommended for breastfeeding or pregnant women [42].

3. Results

4.1. Impact of Plant-Based Diets on Athletic Performance

Findings indicate that Plant-based diets do not negatively impact strength, anaerobic, or aerobic performance compared to omnivorous diets [45,46,47,48].
However, some studies suggest the potential for enhanced aerobic capacity and promote better submaximal endurance in individuals following plant-based diets [11,49,50].
The review by Craddock et al included 8 studies, 7 randomized controlled trials and 1 cross-sectional study, that examined the effects of vegetarian diets on muscle strength, anaerobic and aerobic capacity. Four of these studies assessed both anaerobic and aerobic capacity, three focused on strength training, and one examined the effect of endurance exercises on immune markers. The results indicated that vegetarians and omnivores did not differ significantly in terms of physical performance on the parameters studied. However, limitations of the review,

such as the small number of studies, small number of participants, and short duration of the diets (4 days to 12 weeks), suggest caution in interpreting the results, which may reflect only short-term effects of the diet. Vegetarians were noted to have lower total body creatine and lower plasma carnitine levels, which may affect performance in activities requiring energy from adenosine triphosphate (ATP) and creatine phosphate. Vegans may experience greater performance benefits when supplementing with creatine, but the impact of these differences on physical performance requires further study [9,46].

Another literature review prepared by Juan Hernández-Lougedo et a;. analyzed 6 studies, including experimental, cohort, and cross-sectional studies providing data on the effect of a vegetarian diet on sports performance. The results of the review indicate that athletes on a vegetarian diet achieve higher values of relative oxygen consumption and maximal power compared to meat eaters, suggesting better aerobic capacity. However, no significant differences were observed in parameters related to strength. In addition, women on a vegetarian diet showed higher physical fitness, although these differences were not statistically significant [6].

The study conducted by Heidi M. Lynch et al. investigated the impact of vegetarian and omnivorous diets on physical performance and maximal torque in endurance athletes. A cross-sectional study of 70 adult athletes (27 vegetarians and 43 omnivores) assessed their aerobic capacity (via VO2max testing) and strength (via maximal torque during leg extension). The results indicated that female vegetarian endurance athletes had higher VO2max than their omnivorous counterparts, while there was no difference in men. Maximal torque did not differ between groups. The conclusions suggest that a vegetarian diet can support aerobic capacity and that its effect on athletic performance is neutral. However, the study was limited by the small sample size and variability in physical fitness levels, which depended on experience in the given discipline. In light of these data, a vegetarian diet seems to be appropriate for endurance athletes, but it does not replace quality training [11].

In a later study conducted by Nebl et al., they examined 76 healthy recreational runners assigned to vegan, lacto-vegetarian, and omnivore groups to compare the effects of these diets on exercise performance. Maximal exercise capacity was measured through an incremental exercise test on a cycle ergometer until voluntary exhaustion, with lactate and glucose measurements used as markers of anaerobic metabolism. The results demonstrated no significant differences between the groups in terms of exercise capacity, glucose utilization, or lactate levels across the range from low to maximal effort. The research shows that the diets studied do not have a detrimental effect on performance in recreational runners [48].

The study by Nebl et al. is not fully comparable to the work by Lynch et al. because the latter examined VO2max, and exercise testing was performed on a treadmill. Furthermore, the earlier studies did not measure lactate and glucose as markers of anaerobic metabolism, and did not include a vegan group. But both studies indicate that a vegan diet may be a suitable alternative for ambitious recreational runners [11,48].

The study, which also assessed muscle strength and endurance, was conducted by Hajj-Boutros et al. and involved 56 physically active women—half following a vegan diet and the other half being omnivores. The parameters measured were VO2max, submaximal endurance test, and muscle strength. The results showed that vegans achieved better results in terms of aerobic capacity and sustained endurance at moderate exertion compared to the omnivores (estimated VO2max: 44.5 ± 5.2 vs. 41.6 ± 4.6 ml/kg/min; $p = 0.03$; submaximal endurance time to exhaustion: 12.2 ± 5.7 vs. 8.8 ± 3.0 min; $p = 0.007$). The conclusions of the study suggest that a vegan diet not only does not harm the performance of athletes, but may also promote better submaximal endurance [50].

The results obtained are similar to those in the study by Lynch et al, although higher VO2max levels were observed in mixed vegetarians, not vegans. In both studies, no differences in muscle strength were found between groups [11,50].
A recent randomized crossover trial, SWAP-MEAT, also found no significant differences in primary (12-minute timed run, machine strength) or secondary (VO2 max, push-ups, pull-ups) physical performance indicators among runners and resistance trainers following plant-based diets compared to those on an omnivorous diet. These results are in line with previous studies that have also shown no significant negative impact of plant-based diets on athletic performance, further supporting the idea that plant-based diets can sustain physical performance in athletes [47].

4.2 Impact of Ketogenic diet on Athletic Performance

Burke et al. and Whitfield et al., across four studies involving professional race walkers, reported a decline in athletic performance among athletes adhering to a ketogenic diet. Despite a marked increase in fat oxidation during exercise, these athletes demonstrated inferior outcomes in a 10 km race walk compared to those following a high-carbohydrate diet. The findings suggest that adaptation to a ketogenic diet adversely impacts exercise economy, with the enhanced fat oxidation offering no discernible benefits to athletic performance [51,52,53,54].
Pathak et al., in their review, explained the decline in athletic performance during high-intensity exercise in athletes following a ketogenic diet. A key muscular adaptation during adherence to a ketogenic diet is the upregulation of genes responsible for fat oxidation and energy production. This adaptation may have a beneficial effect during activities with an intensity not exceeding 65% VO2 max. In summary, endurance athletes on a ketogenic diet require a higher oxygen supply to sustain the same training load that athletes on a conventional diet can maintain with lower oxygen consumption. This theory was proven by Shaw et al. in his study. Ketogenic diet impaired exercise efficiency at intensities above 70% VO2max but had no negative effects at lower intensities. Time-to-exhaustion (TTE) did not differ significantly before and after adaptation to either the high-carbohydrate or KD diet [55,56].
Interestingly, McSwiney and Paoli obtained similar results in their scientific studies. They demonstrated no difference in endurance performance between athletes on a ketogenic diet and those on a conventional diet. It was shown that ketogenic diet may have a positive effects on body composition, which may be favorable for athletes struggling with maintaining weight. Athletes who adapted to a ketogenic diet consistently demonstrated higher rates of fat oxidation during exercise. No difference in athletic performance was also shown in CrossFit athletes during a high intensity interval training after four weeks of ketogenic diet [57,58,59].
The work of Wroble KA. et al. proved the negative effect of the ketogenic diet on the power of athletes, but they compared the results in relation to a high-carbohydrate diet, rather than a conventional one. During the study, Wroble divided the subjects into two groups. The first group consumed a ketogenic diet and the second group consumed a high-carbohydrate diet. After four days of using the above diets, it was noticed that people using the low-carbohydrate diet achieved an average of 7% lower peak power, 6% lower average power in the Wingate test. Additionally, the subjects were subjected to an intermittent Yo-Yo test, in which the group using the ketogenic diet achieved an average of 15% shorter distance than those using the high-carbohydrate diet [60].

4.3 Impact of Intermittent Fasting on Athletic Performance

Studies on the effects of intermittent fasting (IF) excluding individuals observing Ramadan are limited. Nashrudin et al. examined the impact of IF on athletes using the Wingate test and high-intensity cycling to exhaustion (HIT) on a cycle ergometer. Participants performed worse in both the Wingate and HIT tests after starting IF; however, by the fourth day, they returned to baseline performance in the Wingate test. During the final, tenth day of testing, Nashrudin observed that participants in the HIT test also gradually began to recover their pre-IF performance levels. He concluded that the body requires approximately four days of IF to begin adapting to changes and gradually restore initial performance capacity [44].

Cornford et al. examined the impact of skipping breakfast, corresponding to the 16/8 IF protocol, on the performance of rowers. An evening measurement of the time required to row 2000m on an ergometer revealed a decline in performance among rowers who skipped breakfast [61]. Similarly, Clayton et al. observed a deterioration in cyclists' performance when skipping breakfast, corroborating Cornford's findings [62].

However, studies do not consistently show negative effects of IF. It was proven that 16:8 IF diet did not negatively affect athletic performance in long distance runners, but decreased their body mass. It was also proven by Tovar that 16:8 IF diet held for four weeks did improve body composition and economy of running without deteriorating effects on athletic performance during 10 kilometer run [63,64].

Many studies on intermittent fasting (IF) are conducted during Ramadan. A systematic review by Trabelsi et al., based on fourteen studies examining the effects of IF on the physical performance of athletes and physically active individuals, highlighted several negative outcomes. Their findings included a decline in exercise test performance, reduced sleep quality and duration, decreased hydration, and a deterioration in athletes' mental state. However, no changes were observed in hematological parameters or lean body mass [36,65].

A systematic review by DeLang M et al. also demonstrated that Muslim football players experience a decline in physical performance during afternoon or evening training sessions conducted during Ramadan, particularly in high-intensity tests and exercises [66].

Aziz et al. not only examined athletic performance but also addressed confounding factors. In contrast to Trabelsi et al.'s findings, Aziz reported no differences in athletes' sleep quality during Ramadan. However, the study noted a decline in sprint performance among football players during 60-minute intermittent exercises conducted while fasting during Ramadan [67].

Grant M et al. investigated the effects of intermittent fasting (IF) on resistance training performance. The IF protocol, maintained at 20:4, had no impact on body composition or muscle mass [38]. Interestingly, results were shown by Moro T et al. on a 16:8 IF protocol during resistance training showed that after 8 weeks of exercise, participants experienced a reduction in fat mass while maintaining muscle mass and maximal strength [68].

4. Discussion

Athletes often express concerns that adopting a new diet may negatively affect their athletic performance. In this review, we have sought to summarize the impact of various popular diets on sports performance to draw preliminary conclusions on this subject.

A plant-based diet provides significant overall health benefits, with specific advantages for athletes, such as improved body composition, enhanced circulation, better glycogen storage, and increased antioxidant capacity, all of which may contribute to improved performance and faster recovery after exercise. The data collected in this study on plant-based diets suggest that a vegetarian diet, including a vegan diet, does not negatively affect physical performance in endurance athletes. In fact, some studies even indicate the potential to improve aerobic capacity and enhance submaximal endurance, particularly in females. Lynch et al. (2016) observed significantly higher VO2 max in female vegetarians, but no such difference was found in men. Similarly, Boutros et al. (2020) found significantly higher VO2 max in female vegans (n=28) compared to omnivores (n=28), attributing this difference to higher carbohydrate intake in the vegan group. These findings highlight the need for further research to better understand the differences between sexes in the context of diet and VO2 max. Research suggests that these diets can serve as a healthier alternative to omnivorous diets without compromising athletic performance. The primary limitations of the reviewed studies were the limited number of original studies available within the specified time frame and the small sample sizes in the analyzed research. Moreover, some studies implemented a short-term plant-based diet, which limits the ability to draw long-term conclusions regarding its impact on physical performance. Typically, dietary patterns are adhered to over extended periods, making long-term studies more representative of real-world practices. This underscores the significant potential for future research on this topic, which could involve a larger number of participants, long-term adherence to standardized diets, a clearer definition of the omnivorous diet used for comparison, and the application of modern techniques for measuring performance.

The ketogenic diet demonstrates potential in specific areas of medicine. However, its implementation requires careful consideration of whether the benefits outweigh the potential risks, including its harmful effects on bone health, cardiovascular function, and physical performance—risks that are particularly concerning for athletes.
As demonstrated by Whitfield et al. and Burke et al. across four different scientific papers, adopting to ketogenic diet reduces the endurance performance of athletes in contrast to individuals following a high-carbohydrate diet. Limitations of the studies include the fact that the research conducted by Burke and Whitfield was highly controlled and carried out over a period sufficient for the body to adapt to the ketogenic diet. However, the studies involved a relatively small number of participants. The limitations mentioned by the authors are minimal and are not expected to have a significant impact on the results reported. Similarly, Wroble et al. examined the adverse effects of this diet on strength and athletic performance, however, his study was conducted over a shorter period of time and without strict control over the participants' intake of the ketogenic diet meals.
McSwiney refuted the decline in athletic performance in his study and demonstrated positive changes in body composition, such as significant body mass loss, which may aid in weight maintenance for athletes. He showed increased critical power presented in watts/kg, although we have to remember that the Ketogenic Diet group in this study lost a significant amount of body mass. These findings highlight that strength maintenance, rather than an increase in absolute force output, may be the primary benefit of this dietary approach in resistance-trained individuals. This scientific paper may spark an engaging debate on finding a balanced approach to reducing athletes' body mass while maintaining their strenght - a skill that could be essential for certain sports. Paoli and Cipryan came up with similar results showing no negative effects on athletic performance. Their studies were limited by small number of participants. In Cipryan's study, participants self-monitored their dietary intake, which limits the standardization of the study. It was explained by Pathak et al. that the ketogenic diet may have a positive effect on sports performance, but primarily in activities where the intensity does not exceed 65% VO2max. The results of Shaw's study align with the theory outlined in the review, demonstrating reduced endurance at intensities exceeding 65% VO_2 max on a ketogenic diet. Although Shaw used a very limited number of participants. This effect warrants further investigation for a more comprehensive understanding and possibly adapting it for athletes of several sports.
Even if the ability to maintain body mass without negatively affecting athletes' critical power proves to be true, it is essential to consider the long-term adverse effects of this diet to prevent potential deterioration in the overall health of its users.

Intermittent fasting (IF) may be an appealing option due to its simplicity, lack of strict dietary rules, and its effectiveness in reducing body weight. However, it is important to consider the potential risks, particularly for individuals with diabetes and pregnant women. It is also important to closely monitor ongoing research regarding the impact of intermittent fasting (IF) on the cardiovascular system. If the findings of Meng Chen et al. are confirmed, IF could potentially be classified as hazardous.
The impact of IF on athletic performance is sport type dependent. Studies suggest that intermittent fasting may have a potentially negative effect on the performance of endurance athletes, though there is a possibility of adaptation over time. However, it is worth noting that results are not uniform, and some studies have reported no significant difference in endurance performance among athletes practicing IF. Further research is necessary to determine the body's capacity for adaptation to physical exercise. In contrast, IF adverse impact on resistance training seems negligible, with the added advantage of promoting fat mass reduction. It should be noted that our conclusion is based on a limited amount of scientific papers, with limitations such as small sample size, inconsistent fasting periods and not strictly controlling fasting itself. It was also stated that negative results during Ramadan may be impacted by other factors than the diet itself such as sleep deprivation or mood changes.
While the potential to reduce fat mass while preserving maximal strength is appealing, caution is necessary due to the possible risks to cardiovascular health. Based on the available studies, it is not possible to definitely determine the impact of diet on athletic performance, and further research is required to clarify these effects.

5. Conclusion

An evaluation of studies exploring the effects of plant-based diets, the ketogenic diet, and intermittent fasting on athletes' physical performance indicates that plant-based diets, such as vegetarian and vegan regimens, not only do not impair but may even enhance aerobic capacity and promote better submaximal endurance. This review suggests that a appropriately planned plant-based diet carries the fewest risks compared to the other diets examined and offers health benefits while potentially positive in influencing aerobic performance, making it a worthwhile alternative to a regular omnivorous diet.
The ketogenic diet, while attractive because of its potential to promote weight loss and benefits in treating neurological conditions, negatively affects performance in high-intensity activities exceeding 65% VO_2max. Additionally, it carries risks related to bone health and cardiovascular function. Nevertheless, it may be advantageous for low-intensity sports below 65% VO_2max, promoting weight loss while preserving critical power.
Intermittent fasting (IF) provides a less certain view of athletic performance., with its effects seemingly dependent on the type of sport. Some research indicates a decline in performance, particularly in endurance sports, others show no difference in performance. For resistance training, IF impact appears minimal. However, due to the limited range and quality of existing studies, more extensive research is needed to clarify the connection between IF and athletic performance.

6. Disclosure

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