PLANT-BASED DIET FOR HIGH-PERFORMANCE ATHLETES: A SCOPING REVIEW

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Abstract. A sedentary lifestyle and consuming unhealthy food can lead to health and wellness issues, resulting in a low quality of life. Nowadays, many references exist to living a much healthier life by eating only plant-based or vegetarian diets. However, the literature review discussing vegan diet interventions for high-achieving athletes is unclear. Therefore, this study aimed to analyze and evaluate studies on vegan diets in high-performance athletes in various countries. Articles were obtained from two electronic databases, Sage and PubMed, then screened and identified according to the inclusion criteria according to the PRISMA ScR flow chart. Articles reviewed were limited to those published in 2019-2023 and in English language only. This systematic scoping review was conducted by the JBI methodology for scoping reviews and the Diffusion of Innovation Critical Appraisal Checklist. A total of 9 original articles met the criteria, consisting of 4 literature reviews, one case study, two experimental study, one cross-sectional study, and one systematic review. Review results reveal that a vegan diet is no better or worse when compared to a non-vegan diet for an athlete. The results show that athletes who eat only plant-based foods can still perform as well as athletes who consume animal and plant-based foods. Evaluation, careful planning, and the support of a nutritionist team are essential for a vegan diet. For athletes whose sports utilize predominantly anaerobic energy systems, studies suggest creatine supplementation (plant-based) improves exercise performance in vegans to a greater

extent than non-vegans. Athletes who go vegan have nothing to lose; it just cannot be done significantly and suddenly. Most of the reasons athletes adopt a plant-based diet are for a long-term healthy lifestyle.

Keywords: vegan, diet, training, sports

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INTRODUCTION

Living in an era that provides many conveniences makes people experience a continuous decline in physical activity (NCD-RisC, 2017). The Sustainable Development Goals (SDGs), one of which discusses health and quality of life, must improve in the future (Tukuitonga and Keller, 2005). Physical activity, diet, lifestyle, and mental health of a person make the foundation of a person's productive life and will have an impact on the individual's level of well-being (Koliaki *et al*, 2018). A sedentary lifestyle and consuming unhealthy food do not lead to a better quality of life, resulting in many diseases that can be contracted, such as obesity, and affecting one's mental health for further impact (Koliaki *et al*, 2018; Wirnitzer *et al*, 2022). These problems are echoed in today's health issues and may be seen everywhere.

In this literature review, we discussed athletes' beliefs to have fitness levels and physical activity above average. Athletes have a much more active lifestyle, with a regular training schedule, rest time, and diet. These conditions support the athlete's performance when competing because his body will be conditioned like a machine that must be ready

to compete in time.

There are many references to living a much healthier life on a plant-based or vegetarian diet. A plant-based diet is a diet consisting mostly or entirely of plant-based foods. It can also include small amounts of animal products, but the majority of the diet is composed of plant. A plant-based diet, either in the form of a vegan or vegetarian diet, provides favorable results for long-term health (Amatori *et al*, 2023; West *et al*, 2023). Athletes will also maintain their performance if they switch to a vegan or plant-based diet, as in the documentary film entitled "The Games Changer" which opens our minds to the fact that food sourced from plants can still maintain and even improve performance in athletes. This is already widely practiced by developed countries. As many as 10% of Europeans (~75 million) adhere to a vegan or vegetarian diet (Mundy, 2021). This review can be used as a reference later for athletes or ordinary people other than athletes who want to become vegetarians. The main questions of this review are (1) ahat are the impacts of plant-based diets on high-performance athletes and (2) what are the differences in the performances between vegan and non-vegan athletes?

MATERIALS AND METHODS

Eligibility criteria for the reviewed articles

This review only included articles with a plant-based or vegan context in high-performance athletes from various sports in different countries. Studies on recreational athletes were excluded.

There was no limitation for the study design of the literature, case study, experimental study, cross-sectional study, and systematic review are subjected to the review.

Search strategy

The search strategies limited only to articles available online. Online searches were conducted on the Sage and PubMed databases. We adopted the studies published in the last five years from 2019-2023 to obtain novelty in the final results of the analysis conducted. The keywords used to enter in the Sage and PubMed databases were "Nutrition", "Exercise", "Food", "Diet", "Cycling", "Plant-based", "Vegan", "Vegetarian", "Athlete", "Body Composition", "Training", "Endurance", "Strength", "Diet Type", "Fruit", "Body Weight", "Lifestyle", "Performance", "Sport" and "Health".

Literatures management

After obtaining numbers of relevant literatures from the databases, the articles were organized into Mendeley reference management, and duplicate articles were removed. At this stage, titles and abstracts were screened by two independent reviewers for assessment against review inclusion criteria. Reasons for the exclusion of sources that did not meet the inclusion criteria were recorded and explained in the PRISMA flow chart. The review included studies evaluating plant-based diets in high-performance athletes from various countries. Exclusion criteria in this review were articles that did not fit the keywords and discussed omnivorous diets and non-athlete research samples. This means that studies on recreational athletes were excluded from this study. Any disagreements between reviewers at any stage of the selection process were resolved through discussion.

Scoping review method

JBI critical appraisal tools were used to assess the feasibility of

individual studies. JBI is an instrument resembling a questionnaire that is used to measure the suitability of an article according to the method used in the research to be reviewed (Joanna Briggs Institute, 2017). The search and study inclusion process results were reported in full in the final scoping review and presented in a flow chart (PRISMA-ScR).

Information extraction

After obtaining articles that are eligible for review, we identified several aspects that can be discussed in accordance with the selected theme including the influence of a vegan diet and the impact of a plant-based diet on athlete performance. Data extracted from the eligible articles were the authors' names and publication year, research purpose, study method, study location, diet protocol, and research findings. These data were later entered into an Excel spreadsheet for comparison purposes.

RESULTS

Fig 1 illustrates PRISMA flowchart utilized in this study. There were 121 titles/abstracts retrieved in the initial search. Sixty-one articles were excluded due to the duplications detected. Of the 60 articles included in the next stage, 51 articles were excluded because the research subjects were not high-performance athletes, they did not discuss plant-based diet, and not all data collection and analysis methods were described. As a result, 9 articles were eligible for the scoping review.

The articles subjected to the scoping review involved various approaches including a literature review, case study, experimental research design, cross-sectional research design, and systematic review. Diverse methods used in those studies yield comprehensive and detailed

results; furthermore, the countries of origin for the research were also broad and diverse.

Three studies were conducted in the United Kingdom. Other studies reviewed were conducted in Ireland (n = 1), Italy (n = 1), Poland (n = 1), Canada (n = 1), United States (n = 2). In term of study design, they were literature reviews (n = 4), case study (n = 1), experiment (n = 2), cross-sectional study (n = 1), systematic review (n = 1). There were two studies published in 2023, one published in 2022, one published in 2021, two

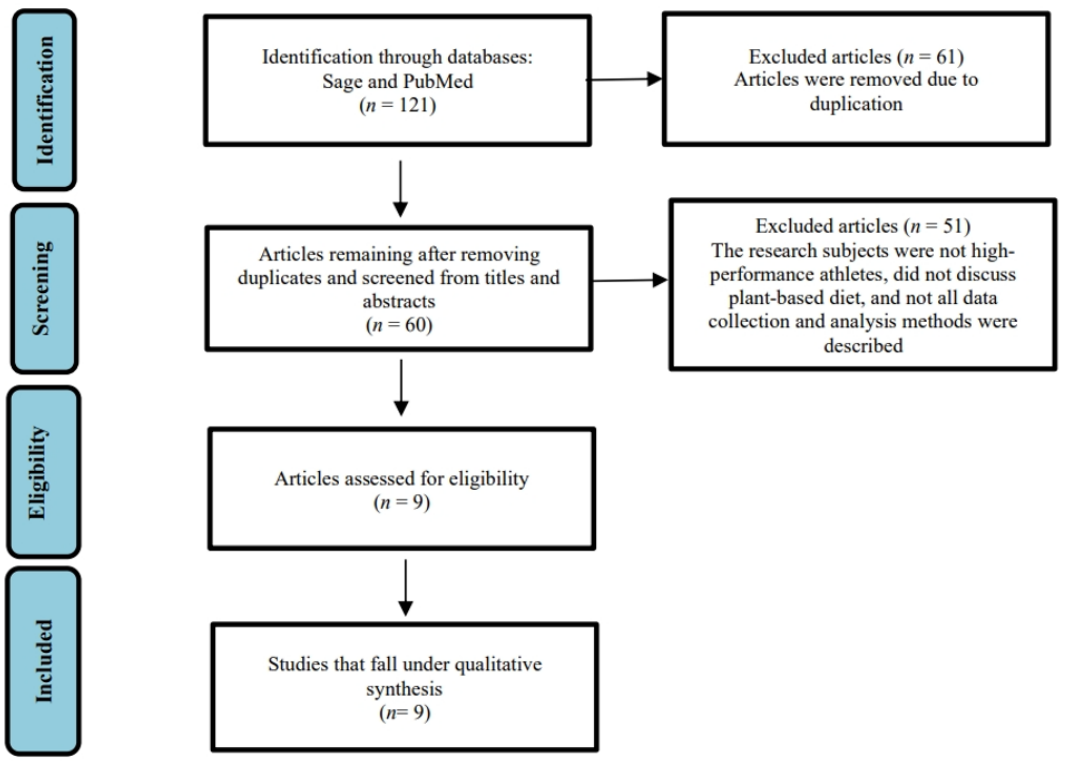

Fig 1 - PRISMA flow diagram of the systematic search and data extractions

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

published in 2020, and three published in 2019. Seven studies reviewed used standard instruments to measure and analyze nutrition levels and plant-based diets; only two used original instruments developed by the researchers.

This study reviews the impact of vegan and non-vegan diets on the nutritional adequacy of high-performance athletes. Broadly speaking, the results of the nine articles showed that there was no difference between the performance of athletes consuming vegan and non-vegan diets. Athletes can still meet nutritional targets when switching to a vegan diet without sacrificing key performance indicators obtained on a non-vegan diet. All studies reviewed also address designing a vegan diet that suits the needs of athletes. Table 1 summarizes the reviewed articles.

The articles reviewed discussed mixed results regarding plant-based diets in athletes, including how they impact their bodies. One article explains that plant-based diets can favor cardiovascular health, which plays an essential role in athlete endurance (Barnard *et al*, 2019). Another article mentions that the large amount of protein found in certain plants enriches the daily nutritional intake of vegans and vegetarians in particular, which can also be a rich source of nutrients for athletes (Jakubczyk *et al*, 2022). One article reviews the development of a tool called a 'vegetarian food guide' to help nutritionists plan vegetarian diets for athletes (Baroni *et al*, 2023). The tool contains several food composition segments. These segments do not represent the quantity of food, as the amount is adjusted for body weight. They only represent what food groups are recommended for athletes to consume.

One of the articles reviewed describes the disadvantages and advantages of vegan dietary patterns in athletes. The results of that review show that applying food restrictions to athletes can have a negative impact because it narrows the options for practically providing

Table 1

Summary of reviewed articles

Reference	Study method	Study location	Diet protocol	Research purpose	Research findings
Baroni *et al*, 2023	Experiment	Italy	Vegetarian	To provide a handy vegetarian food guide, VegPlate for Sports, which allows nutritionists to plan vegetarian diets for athletes by instantly checking its content in energy, macronutrients, and micronutrients	VegPlate for Sports is suitable for male and female athletes who follow a vegetarian diet (ie lacto-ovo and vegan), as it provides adequate and weight-based diet planning.
Barnard *et al*, 2019	Literature Review	United States	Plant-based	To explore the role of nutrition in providing heart protection, with a focus on plant-based diets previously shown to provide heart benefits	A plant-based diet is critical to cardiovascular health, which is especially important for endurance athletes. In particular, these diets improve plasma lipid concentrations, blood pressure, body weight, and blood glucose control as part of a healthy lifestyle. The possibility that such diets may contribute to improved performance and accelerated recovery in endurance sports is enhanced by their effects on blood flow, body composition, antioxidant capacity, systemic inflammation, and glycogen storage. These attributes provide a scientific foundation for endurance athletes' increased use of plant-based diets.

Table 1 (cont)

Reference	Study method	Study location	Diet protocol	Research purpose	Research findings
Davey *et al*, 2021	Case study	Ireland	Vegan	To determine the level of performance and body composition changes when adopting a non-vegan to vegan diet	With adequate knowledge, education, proper planning, commitment, and repeated feedback, athletes can meet nutritional targets on a vegan diet without compromising key performance indicators obtained on a non-vegan diet. After transitioning to a vegan diet, elite athletes' performance and body composition can be maintained. However, it was also recognized that the athlete, in addition to motivation, also received considerable support in terms of personal nutrition consultation and support from his teammates.
Gibson-Smith *et al*, 2020	Cross-sectional study	United Kingdom	Vegan and vegetarian	To assess athlete climbers' vegan, vegetarian, and non-vegan food intake, body composition, and iron status	There was no significant correlation between daily energy intake and training volume. Approximately 17% of men (n=3) and 45% of women (n=9) had suboptimal iron status. Thirty percent of women met the criteria for iron deficiency classification. Mean serum ferritin was significantly greater in males than females and significantly lower in vegan/vegetarian than non-vegan female climbers. These findings suggest that experienced hikers are at risk of energy restriction and iron deficiency. Therefore, regular assessment of nutritional status is necessary.

Table 1 (cont)

Reference	Study method	Study location	Diet protocol	Research purpose	Research findings
Jakubczyk *et al*, 2022	Experiment	Poland	Vegan and Vegetarian	To determine the dietary fiber and total protein content of edible flowers and compare the nutritional content of herbaceous vs woody plants	A large amount of protein is found in olive family (Oleaceae) flowers and woody plants that can enrich daily diets, especially for vegans and vegetarians. Edible flowers from the Asteraceae family contain high levels of total dietary fiber, which can be a rich source of nutrients in the daily diet of athletes. Woody plant flowers, especially from the Oleaceae family, are a valuable protein source. Due to their versatile nature, edible flowers can be used as functional foods for athletes.
Kaviani *et al*, 2020	Systematic review	Canada	Vegetarian	To determine the effects of creatine supplementation in vegetarians.	Creatine supplementation in vegetarians increased creatine and total phosphocreatine concentrations in vastus lateralis and gastrocnemius muscles, plasma, and red blood cells higher than non-vegans. Creatine supplementation increased lean tissue mass, type II fiber area, insulin-like growth factor-1, muscle strength, muscle endurance, and brain function (memory and intelligence) in vegetarian participants. Studies suggest creatine supplementation improves exercise performance in vegetarians to a greater extent compared to non-vegans.

Table 1 (cont)

Reference	Study method	Study location	Diet protocol	Research purpose	Research findings
Lis *et al*, 2019	Literature review	United States	Gluten-Free, Low FODMAP, Vegetarian, and Fasting	To determine the most appropriate type of plant-based diet to minimize the risks associated with unnecessary dietary restrictions, potentially more harmful to the health and performance of Track-and-Field athletes	Overall, each diet protocol should be evaluated not to pose a risk to the athlete's health and performance. To optimize elite performance nutrition during the dieting process, guidance from an accredited dietitian/nutritionist and advice from appropriate medical and sports science personnel should be sought before implementing the dieting process.
Rogerson, 2017	Literature review	United Kingdom	Vegan	To establish and design vegan diets to achieve the dietary needs of most athletes and sportspeople for optimal health and performance through the development of sports nutrition knowledge	Through designing a vegan diet according to nutritional knowledge and managing food choices with particular attention paid to energy, macro-, and micronutrient attainment, along with proper supplementation, a vegan diet can satisfactorily meet the needs of most athletes. Supplementation with creatine and β-alanine can enhance performance effects in vegan athletes.

Table 1 (cont)

Reference	Study method	Study location	Diet protocol	Research purpose	Research findings
West *et al*, 2023	Literature review	United Kingdom	Vegan	To assess whether adopting a vegan diet is likely to affect optimal nutritional requirements negatively	Current evidence does not support that a vegan diet will improve athletes' performance, adaptation, or recovery. However, it also suggests that athletes can follow a (more) vegan diet without disadvantages. Spontaneously consumed vegan diets may lead to a suboptimal intake of critical nutrients, especially the quantity and quality of dietary protein and certain micronutrients (*eg* iron, calcium, vitamin B12, and vitamin D). Thus, optimal vegan sports nutrition requires (more) careful consideration, evaluation, and planning.

nutrition, resulting in less-than-optimal nutritional fulfillment (West *et al*, 2023). In line with these findings, an article written by Gibson-Smith *et al* (2020) explains that athletes with plant-based diet consumption patterns are at risk of energy and iron deficiency. Therefore, athletes who implement a plant-based diet pattern are recommended to be accompanied by a nutritionist and regular nutritional status assessments, and adequate knowledge and proper planning are needed to maintain athlete performance (Davey *et al*, 2021; Gibson-Smith *et al*, 2020). This is in line with the Lis *et al* (2019) who stated that guidance from a dietitian/nutritionist and advice from appropriate medical and sports science personnel should be applied before implementing the dieting process. The findings obtained are that supplements that can improve exercise performance in vegetarians are creatine and β-alanine (Kaviani *et al*, 2020; Rogerson, 2017).

DISCUSSION

Athletes may follow different diets depending on their specific goals and requirements. Each type of diet has advantages and disadvantages, and athletes need to choose a diet that suits their goals and needs. Some popular diets among athletes include a high-carbohydrate diet, which is the diet typically followed by endurance athletes, as carbohydrates provide a quick source of energy for prolonged physical activity (Burke *et al*, 2011). High-protein diets are often followed by athletes looking to build muscle mass or recover from injury (Phillips and van Loon, 2011). Ketogenic diets are low-carbohydrate and high-fat diets and are followed by some athletes to improve endurance and weight loss (Volek *et al*, 2015). Plant-based diets eliminate animal products and can usually be followed for ethical, environmental, or health reasons (Melina *et al*, 2016).

According to Wirnitzer *et al* (2022), available population statistics show that, in 2019, 12% of Europeans followed a vegetarian diet. Wirnitzer *et al* (2022) reports that 6% of the US population is vegetarian (lacto-ovo vegetarians and vegans), and about 10% of Europeans adhere to some vegetarian diet. These diets are popular, especially among the younger generation. As a result, a social group or athlete likely is a vegan. The demand among athletes for plant-based diets shows a growing trend. A survey of over 300 athletes conducted by researchers at the University of Winchester found that 33% of respondents were interested in following a lacto-ovo-vegetarian or vegan diet (Wirnitzer *et al*, 2022). In contrast, another 29% was less interested in following a lacto-ovo-vegetarian diet (Craddock *et al*, 2016).

Similarly, a survey of over 200 endurance athletes by researchers at the University of Oxford found that 33% were lacto-ovo-vegetarians or vegans (Craig, 2009). In recent years, more and more athletes, including famous professional athletes such as Lewis Hamilton and Novak Djokovic, have stated that they follow a vegetarian (lacto-ovo or vegan) diet for health, ethical, or environmental reasons (Baroni *et al*, 2023; Craig, 2009; Melina *et al*, 2016; Nebl *et al*, 2019a).

Health benefits such as reduced risk of heart disease, low-density lipoprotein (LDL), blood pressure, type II diabetes, and cancer make vegan diets increasingly adopted by many people (Appleby and Key, 2016; Marsh *et al*, 2012). However, a poorly constructed vegan diet can cause individuals to develop macronutrient and micronutrient (vitamin B12 and vitamin D; iron, zinc, calcium, iodine) deficiencies (Appleby and Key, 2016; Clarys *et al*, 2014; Craig, 2009; Marsh *et al*, 2012). Managing energy balance is thus essential for all athletes, but this issue is likely to be further exacerbated when habitual dietary patterns promote early satiety and reduce appetite, such as vegan diets (Clarys *et al*, 2014; Craig,

2009; Fuhrman and Ferreri, 2010; Marsh *et al*, 2012; Nebl *et al*, 2019b). Data shows that vegans produce fewer calories than omnivores (Clarys *et al*, 2014). One of the consequences of a vegan diet is an increased feeling of fullness and a reduced appetite, which can be beneficial for losing weight (Turner-McGrievy *et al*, 2007). It has been suggested that some endurance athletes may deliberately adopt a vegan diet to meet their carbohydrate needs or to aid weight management goals (Fuhrman and Ferreri, 2010; Mangels *et al*, 2011; Venderley and Campbell, 2006). Vegans are at higher risk of fracture due to lower calcium intake (Iguacel *et al*, 2019). Indeed, the importance of calcium for vegan athletes reflects its role in maintaining bone health during exercise weight-bearing (Leachman Slawson *et al*, 2001). To fulfill the above requirements, vegan athletes should consume sufficient amounts of plant-based calcium sources such as chickpeas, beans, and green vegetables.

As described by Davey *et al* (2021) and Rogerson (2017), athletes who choose to adopt a vegan diet can still meet their nutritional needs if the design of the vegan diet is by nutritional knowledge and management of food choices with particular attention paid to energy, macro, and micronutrient attainment, along with appropriate supplementation. Vegan diets can satisfactorily meet the needs of most athletes and can enhance performance effects. A vegan diet can provide all the nutrients necessary for optimal health, including protein, iron, calcium, and vitamin B12 (Melina *et al*, 2016). There is some evidence to suggest that plant-based diets can lead to improved performance in track and field athletes and faster recovery times after exercise (Fuhrman and Ferreri, 2010; Wirnitzer, 2020; Melina *et al*, 2016; Shaw *et al*, 2022). For example, a study by Craddock *et al* (2016) found that a vegan diet was associated with better endurance performance in elite female runners. A vegan diet can be an effective way to manage weight. Vegan diets tend to be lower

in calories and fat and higher in fiber, which can help promote satiety and weight loss (Barnard *et al*, 2019; Turner-McGrievy *et al*, 2015). An observational intervention study conducted by Craddock *et al* (2016), in which subjects adopted a vegetarian or non-vegetarian diet for several weeks, failed to find significant differences on athlete performance. In terms of aerobic and anaerobic performance parameters, the discussion of vegetarian diets in sports has the aim of general health and disease prevention, apart from performance enhancement (Meyer and Reguant-Closa, 2017). Long-term consumption of a vegetarian diet can improve recovery, prevent inflammation, and reduce oxidative damage that occurs in intense exercise (Trapp *et al*, 2010). A well-implemented vegan diet can support recovery and adaptation from exercise and foster muscle hypertrophy as part of an endurance training program (Elliot *et al*, 2006; Joy *et al*, 2013). Considering all this, there is no specific reason or scientific evidence to suggest that a vegetarian diet is better or worse when compared to an omnivorous diet for an athlete (Burke *et al*, 2011; Venderley and Campbell, 2006). As such, the basic principles of a vegetarian diet remain the same as a non-vegetarian diet, with the exact timing requirements, quality, and quantity of macronutrient choices, hydration, and supplements (Rogerson, 2017; Thomas *et al*, 2016).

Based on Davey *et al* (2021), it can be summarized that athletes who eat only plant materials can still perform as well as athletes who consume food from animals and plants (Davey *et al*, 2021). In addition, during recovery, protein is needed; animal and plant protein sources in productive age do not have a significant gap in this regard (Monteyne *et al*, 2023). What needs to be observed is careful consideration, evaluation, planning, and support from the nutritionist and team in carrying out a vegan diet. This diet cannot be done suddenly; it is better if done gradually. Female athletes are at risk of energy restriction and iron

deficiency; therefore, regular assessment of nutritional status is needed to monitor the state of athletes. Related research also discusses that plant-based or vegan diets are not recommended for the elderly because old age requires essential amino acids sourced from animals (Magkos *et al*, 2014). Whereas in men, plant-based diet does not affect their masculinity, even the risk of developing cardiac disease can be reduced, and they have a better quality of life (Aavik and Velgan, 2021). For sports that predominantly use aerobic energy systems or endurance, plant-based diets play a crucial role in a healthy lifestyle, especially heart health. Not only for health and reducing obesity, but eating plant-based foods can also reduce negative ecological impacts (Domić *et al*, 2021). This diet improves plasma lipid concentrations, blood pressure, body weight, and blood glucose control. For athletes whose sports utilize predominantly anaerobic energy systems, studies suggest creatine supplementation (plant-based) improves sports performance in vegetarians to a greater extent than non-vegans (Rogerson, 2017). Athletes who choose to be vegan have nothing to lose; it is just that it cannot be done significantly and suddenly. It is recommended gradually and consistently. A spontaneous vegan diet can lead to suboptimal intake of critical nutrients, especially the quantity and quality of dietary protein and certain micronutrients (eg iron, calcium, vitamin B12, and vitamin D) (Davey *et al*, 2021).

In conclusion, this literature review shows that articles discussing plant-based diets revealed mixed findings. One of the main results found was that a vegan diet is no better or worse than a non-vegan diet for athletes. According to the results, athletes who consume only plant-based foods can still perform just as well as athletes who consume both animal and plant-based foods. However, it is essential to note that careful consideration, evaluation, planning, and the support of a nutritionist team are essential for a vegan diet. For athletes whose sports

utilize predominantly anaerobic energy systems, studies suggest creatine supplementation (plant-based) improves exercise performance in vegans to a greater extent than non-vegans. Athletes who choose to go vegan have nothing to lose; it is just that it cannot be done extremely and suddenly but it is recommended gradually and consistently. Athletes adopt a plant-based diet for a long-term healthy lifestyle, such as reduced risk of heart disease, lower LDL, blood pressure, type II diabetes, and cancer.

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CONFLICT OF INTEREST DISCLOSURE

All authors declare no conflict of interest.

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