

## Vegetarian Diet among Athletes on Nutrient Adequacy and Performance: Literature Review

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### ABSTRACTS

The objective of this study is to determine the effects of vegetarianism (vegan and semi-vegetarian) among athletes on their nutrient sufficiency and performance. This review is conducted with three steps, namely: literature search and screening; data extraction and analysis; and writing the literature review. The results show that athletes practicing a vegetarian diet may be at a greater risk of nutritional inadequacy especially proteins, essential fatty acids, iron, zinc, calcium, iodine, vitamin D, and vitamin B<sub>12</sub>. Whilst the effect of vegetarian practice in athletes' performance has no significant difference with omnivore athletes. vegetarian athletes should plan a well-planned diet to meet the recommendations of macro and micronutrients for the training and recovery phase. At last, vegetarianism in athletes does not affect their performance and their nutritional sufficiency can be maintained by planning well-balanced dietary consumption. Further research is required to broaden our understanding of vegetarianism in athletes

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## **1. Introduction**

Vegetarianism is the dietary practice that eliminates meat (including poultry, fish, and seafood) and possibly other animal-derived foods and beverages. Vegetarian diets can be divided into some categories: lacto-ovo vegetarian (with dairy and eggs), Lacto-vegetarian (with dairy), ovo-vegetarian (with eggs), and vegan (void of all animal products) (1,2). Implementing a vegetarian diet may result in a shortage of energy intake or of specific nutrients including omega-3 fatty acids, iron, zinc, calcium, vitamin D, iodine, and vitamin B<sub>12</sub>. These nutrients are lack in plant foods or are less well absorbed from plants compared with animal sources (3,4).

The published study in elite athletes indicated that 8% of international athletes followed a vegetarian diet—1% being vegan (5). Some athletes have adopted a vegetarian diet to acquire the health benefits associated, but also believe the diet may assist in achieving appropriate carbohydrate intake, weight management, and other performance-enhancing advantages (6). A balanced diet plays an important role for athletes. Vegetarian athletes need to consume a wide variety of foods in their diet to obtain the essential nutrients needed for health and sports performance (7,8).

Several studies have been published investigating the effects of a vegetarian diet on athletes' performance but it's not extensively studied, lack of scientific data, and produced inconsistent results (5,9,10). The following review will discuss the implementation of vegetarian diets among athletes on their nutritional adequacy and performance.

## **2. Literature Review**

### **2.1. Variety of Vegetarian Diets**

Vegetarianism refers to a variety of diets that are classed depending on how restricted they are. Vegetarianism is generally defined as the avoidance of meat in one's diet, but other less stringent eating patterns can also be labeled as vegetarianism. Flexitarians, for example, eat meat only sometimes, perhaps once a week; pescatarians, who forgo all meat except fish and shellfish; and ovolactovegetarians, who eschew all sorts of meat but eat animal products such as eggs and dairy products. A rigorous vegetarian diet, on the other hand, eliminates all animal-based items. Veganism is a broad term that encompasses the adoption of a strict vegetarian diet as well as the avoidance of various consumer goods derived from animal products, such as cosmetics. (11)

In the literature, there are many different forms of vegetarian diets. The most widely accepted classification includes four types: (1) flexitarian or semivegetarian diets, in which people eat meat sporadically (up to once a week) or exclude red meat but consume white meat; (2) pesco-vegetarian or pescatarian diets, which exclude all meats except fish and seafood; (3) ovolactovegetarian diets, which exclude all types of meat but allow animal-derived products such as dairy products and eggs; and (4) strict vegetarian diet. (12)(13)

Other diets can be considered subclassifications of vegetarianism in addition to these: (1) raw vegan diet, which is largely centered on food in its most natural (raw) state, with an emphasis on fruits and vegetables.(14)

### **2.2. Vegetarian Athletes**

Fuhrman & Ferreri (2018) these are just a few of the many world-famous vegan athletes. This diet, as can be demonstrated, improves performance in strength and endurance sports. Many research have been conducted to see how a vegan diet affects the body's performance (15). Athletes who compete in endurance events have different requirements than those who compete in strength events. Instead of testing real performance at athletic events, some

studies look at maximum oxygen uptake, strength, blood acid-base status, acute MPS, and chronic muscle growth to see if food can have an indirect impact on performance. Others, such as time to exhaustion when cycling, track performance outcomes.(16)

### 2.3. Athlete performances

Craddock and colleagues [17] reviewed the majority of the literature on vegetarian diets with strength, anaerobic, and aerobic exercise to date. There were eight studies in total. Three of the studies looked at strength training, four looked at anaerobic and aerobic performance, and just one looked at the impact of endurance exercise on immunological markers. There was no change in anaerobic or aerobic strength. In terms of several measurements and types of activity, it was discovered that exercise performance did not appear to change between dietary 214 groups. Only the reduced total creatine content and plasma carnitine levels in vegetarians appear to be significant. When vegans consume creatine in the form of adenosine, they are more likely to improve their performance. (17)

## 3. Materials and Methods

This journal is a literature review study which started with literature search and screening. The keywords used in this step were vegetarian athletes, nutritional adequacy, nutritional status, and athletes performance. After literature screening was conducted, approximately about 48 articles were collected through several sites, such as Elseviers, Science Direct, PubMed, and Research Gate. Data extraction and analysis was done by gathering and extracting applicable information from the primary study. The relevant and important information was used in the process of writing this review.

## 4. Results and Discussion

### 4.1. Reasons for the vegetarian lifestyle in athletes

The fulfillment of nutritional needs in athletes is a top priority to maintain athletes' conditions and performances. Optimal nutritional intake can meet high energy expenditures, maintain body homeostasis, prevent post-training stress, achieve ideal body composition, and maintain athletic performance (18). Demands for athletes to win in competitions require them to do various ways to maintain their performances. One of the efforts made is by adopting a vegetarian diet. Several studies have shown that a vegetarian diet can improve the cardiovascular system and blood circulation, and increase antioxidant levels (19).

Vegetarian practices can increase the intake of complex carbohydrates, fiber, antioxidants, and phytochemicals, and also can reduce saturated fat and cholesterol intake (20). Athletes choose to adopt a vegetarian diet to maintain health and improve performance. Endurance athletes, such as triathletes, marathon runners, and cyclists tend to choose a vegetarian diet to increase complex carbohydrates intake and maintain body weight (21).

Other factors that lead to the choice of vegetarian practices in athletes such as religious beliefs, cultures, food allergies to certain foods, and avoidance of certain types of food. Hindu athletes choose to be vegetarian since their religion forbids them to consume red meat. Athletes who come from Africa tend to adopt a vegetarian diet because they rarely eat animal-sourced foods. Athletes based on weight categories tend to practice a vegetarian diet or only consume white meat (poultry and fish) as a source of animal protein (5).

### 4.2. Types of vegetarianism in athletes

Vegetarian is a diet that is carried out by consuming plant-sourced foods, such as vegetables, fruits, seeds, nuts, and not consuming animal-sourced foods (22). Table 1

presents the types of vegetarian diets.

**Table 1** Types of vegetarianism

Types	Description
Flexitarian	Periodically consume animal-sourced foods (meat, poultry, fish, eggs, and dairy products)
Pesco-vegetarian	Do not consume any animal-sourced food except for fish
Lacto-ovo-vegetarian	Do not consume any animal-sourced food except for eggs and dairy products
Lacto vegetarian	Do not consume any animal-sourced food except for dairy products
Ovo vegetarian	Do not consume any animal-sourced food except for eggs
Vegan	Do not consume any animal-sourced food
Macrobiotic vegetarian	Various limitations; Animal-sourced foods that are allowed to be consumed are the small ones, such as fish
Fruitarian	Eat fruits, nuts, seeds, and some vegetables

Improper practices of vegetarian diets cause the limitation of animal-sourced foods consumption, which leads to the deficiency of nutrients, especially protein, fatty acids, iron, calcium, zinc, iodine, vitamin D, and vitamin B<sub>12</sub>.

#### 4.3. Adequacy of nutrition based on intake

Athletes tend to have high-activity levels, so their nutritional needs tend to be higher than ordinary people. In general, nutritional needs can be met through the application of balanced nutrition. Athletes' nutritional needs are influenced by various factors, including activity level, body mass, and the type of exercise performed. Nutritional intake that does not meet nutritional needs can affect and lower their performances. Vegetarian practices in athletes, if not done properly, can lead to various nutritional problems, which can affect athletes' performances (7).

Athletes' energy needs must be fulfilled through healthy food consumption to achieve energy homeostasis. However, negative energy balances are still common in athletes, especially in endurance athletes, weight-making athletes, and aesthetic sports athletes. The energy intake of athletes who perform vegetarianism tends to be lower than other athletes because vegetarian athletes do not consume animal-sourced foods and tend to consume high-fiber vegetables which have low energy density and provide longer satiety. Unmet energy needs can decrease athletes' performances, unwanted weight loss, changes in body composition, and deficiency of macronutrients and micronutrients (7,23,24).

Protein has a very important role in the process of muscle synthesis, especially in the recovery process for athletes after exercise. The protein adequacy of vegetarian athletes tends to be lower than that of non-vegetarian athletes since their protein needs are only met from plant-sourced protein. Although there is a tendency for vegetarian athletes to consume more protein than recommended because the source of protein consumed comes from vegetable protein, which generally has low quality and digestibility so that the athlete's need

for essential amino acids is not met (25,26). Vegetable protein sources do not have a complete amino acid composition, such as BCAAs, which are amino acids found in food sources of animal protein. BCAAs help in the stimulation of muscle cell synthesis during exercise (27).

Fat is a source of energy that also functions in the absorption of fat-soluble vitamins (vitamin A, D, E, and K), building blocks of body structure, hormone production, and other physiological processes (28,29). Vegetarians tend to eat less fat from foods, especially vegans who eat no animal foods at all. Saturated fat intake in the vegan group was lower than the omnivore group. The results of the study [7] showed that fat intake in the vegan group was lower than the Lacto-Ovo vegetarian and omnivore groups. Besides, sources of essential fatty acids, such as EPA and DHA were also higher in the omnivore and Lacto-ovo groups of vegetarians, compared to vegans. EPA and DHA fatty acids play a role in cardiovascular function and cognitive health (30).

Fiber intake in vegetarians was significantly higher than the omnivore group due to the high intake of fruits, vegetables, and whole-grains. Results show that fiber intake in the omnivore group is less than half of the vegan fiber intake and is still below the recommended daily fiber intake (7). The high intake of fiber in the vegetarian group causes high satiety. This can increase the risk of vegetarian athletes having a lower energy intake than their actual needs (31).

Athletes who perform a vegetarian diet are also at risk for having low intakes of iron, zinc, calcium, vitamin B12, and vitamin D. Generally, these micronutrients can only be obtained by consuming animal-sourced foods. The need for these nutrients can usually only be met through supplementation (7). Generally, the iron sufficiency of vegetarian and omnivore athletes has the same value. However, the type of iron that is generally consumed by vegetarians is non-heme iron, which comes from vegetables, where this type of iron has low availability and cannot be utilized directly by the body, so its absorption is low (32). Iron in the blood is stored in the form of ferritin which functions to maintain iron homeostasis in the body. Vegetarian dietary practices, especially vegan, have lower blood ferritin levels than omnivorous diets (33). Low ferritin levels can reduce blood hemoglobin levels and increase anemia risks.

Zinc intake for vegetarian athletes is fulfilled through the consumption of legumes, whole grains, nuts, soy, seeds, and dairy products. Even though the intake has met daily needs, zinc from non-animal foods has low bioavailability due to the presence of phytate, so its absorption in the body will also be low (34). Vitamin B<sub>12</sub> has functions in the production of red blood cells, tissue repair, protein synthesis, and nervous system homeostasis. Vegetarian athletes tend to have low serum B<sub>12</sub> concentrations as a result of the low consumption of animal-sourced foods. Deficiency of this vitamin can result in a decrease of O<sub>2</sub> transport in the blood, leading to macrocytic anemia, and if prolonged, it can lead to neurological disorders [18]. Calcium and vitamin D play important roles in maintaining bone health and the regulation muscle system, which is crucial for athletes. Athletes who practice vegan and do not consume animal-sourced foods, especially dairy products, will have low reserves of vitamin D and calcium, resulting in decreased bone mass and muscle synthesis (35,36).

#### 4.4. Protein and micronutrients sources for vegetarian athletes

Nutrient adequacy is still an important consideration for vegetarian athletes. Theoretically, individuals who change from omnivorous to plant-based diets typically improve their overall nutrition since fruits, vegetables, beans, and whole grains tend to be high in vitamins, minerals, and fiber, very low in saturated fat, and devoid of cholesterol

(19). In contrast, the results studies showed that athletes practicing a vegan and semi-vegan diet may be at a greater risk of nutritional inadequacy especially proteins, essential fatty acids, calcium, iron, zinc, iodine, vitamin B12, and vitamin D (3).

Athletes have a higher protein requirement than normal people because of the enhanced utilization of amino acids in oxidative energy production during physical exercise (37). Protein requirements in a diet consist exclusively of less well-digested plant sources, such as whole legumes and unprocessed grains versus well-digested sources including soy, dairy, or egg protein (38). Soy foods (e.g., tofu, tempeh, soy milk, veggie burgers, etc.) and legumes (e.g., kidney, pinto, black, and garbanzo beans) offer the highest quality plant protein and some of each should be consumed daily (39).

Fat is also an important component of the athlete’s diet, specifically, it needed to ensure adequate intake of plant-based sources of omega-3 fatty acids through the selection of omega-3-rich foods and replacing omega-6-rich oils (40).

Depending on food choices, however, meeting daily requirements for iron, zinc, calcium, and vitamin B<sub>12</sub> may be challenging. Iron and zinc are important for optimal performance and growth. Both minerals are vital for a healthy immune system; plus adequate iron is needed to build healthy red blood cells and avoid the fatigue associated with iron deficiency anemia. Legumes, whole grains, soy foods and fortified breakfast cereals contribute significant amounts of both (39,41).

Calcium plays a role in bone health, helps muscles relax and contract and nerves conduct messages. Athletes age 18–50 need at least 1,000 milligrams of calcium daily. Calcium from plant foods divided into three groups based on their bioavailability compared with cow’s milk consists of low, moderate, and high bioavailability. Vitamin D, which as an enhancer in calcium absorption, may also be deficient due to reduced intake of fatty fish, vitamin-D-fortified dairy products, and limited sun exposure (particularly during indoor training seasons) (3,39).

Iodine is a red flag mineral for many vegans and vegetarians who avoid table salt (typically fortified with iodine), limit cow’s milk consumption, or consume plant foods grown in iodine poor soil (42). Finally, vitamin B<sub>12</sub> is a concern for vegan and semi-vegan athletes because it is found exclusively in animal products. B<sub>12</sub> is needed for healthy red blood cells and nerve fibers. Vegan athletes should consume vitamin B<sub>12</sub>-fortified foods daily or take a vitamin B<sub>12</sub>-containing supplement or multivitamin. Vegetarian athletes should consider taking a supplemental source if their intake of dairy products and/or eggs is limited (3). Table 2 describes the sources of the key nutrients in vegetarian.

**Table 2** Key Nutrients Sources in Vegetarian

Nutrients	Nutrient Sources
Protein	Lentils, peas, soy products (tofu, tempeh), beans, nuts, nut butter, dairy products, most soy/plant-based “milk”
Essential Fatty Acids	Nuts, walnuts, nut butter, seeds: flaxseed, chia seed, and hemp seeds, avocado, olive oil, other oils
Calcium	High bioavailability: Chinese cabbages, kale, texturized vegetable proteins. Average bioavailability: Dairy products, calcium-set tofu. Low bioavailability: Fortified soymilk, most nuts, seeds, beans.

Nutrients	Nutrient Sources
Iron	Beans, peas, lentils, edamame, nuts, seeds, many grain products, fortified bread, breakfast cereals
Zinc	Beans, peas, lentils, nuts, seeds, edamame
Iodine	Iodized salt, seaweed, dairy products, eggs
Vitamin B <sub>12</sub>	Nutritional yeast, soymilk, plant-based “milks,” fortified meat analogs, shiitake mushrooms
Vitamin D	Fatty fish, vitamin D-fortified cereals, margarine, plant-based “milks”

In the case of protein, vitamin, mineral, and trace element inadequacy intakes as a result of implementing vegetarian diets in athletes, the energy-dense processed foods or supplementation can be necessary, although it will not enhance performance, at least, will ensure adequate nutrient status (3,37). Calcium, iron, vitamin B<sub>12</sub>, and vitamin D were commonly consumed supplements (7).

#### 4.5. Nutritional status and supplementation on vegan athletes

Athletes have a specific picture in terms of meeting their daily nutritional needs (43). Fulfilling these nutritional needs aims to improve the athlete's performance and mental health optimally. Included in the selection of the type of diet chosen by athletes is aimed at meeting energy needs, macronutrient sources, and micronutrients that are adjusted to the training periodization time (44).

Diet is known to affect a person's nutritional status. Likewise for athletes, choosing foods that are rich in nutrients will reduce the risk of nutrition deficiencies that can interfere with the health and performance of an athlete, especially if the athlete lacks energy, and will have an impact on reducing body mass and the amount of fat (45). The diet is chosen based on a person's needs and goals, according to states, that there are athletes who chose to become a vegetarian with health goals. A vegetarian diet is known to have the characteristics of consuming nutrients rich in oligo and polysaccharides, fiber, fruits, and vegetables as well as high antioxidant and phytochemical content and low in saturated fat and cholesterol when compared to an omnivorous diet (6,10).

The use of dietary supplements for athletes is not an alternative fulfillment of nutrients for athletes who have insufficient nutrient intake, this is according to Maughan & Shireffs (2011) Supplements can be consumed if in the short term, due to changes in diet required within a certain period of time. Supplement consumption for athletes is used based on needs, for example with the aim of maximizing performance, delaying fatigue, changing physical form and improving health. A vegetarian will certainly manage to consume less protein sources and can lead to iron deficiency, if athletes with iron deficiency reduce protein sources, and replace protein sources with supplements, these athletes will not get the maximum benefit, especially in increasing endurance and muscle mass (43).

Athletes think that nutrition is important, but sometimes they ignore it and fail, and realize that nutritional fulfillment is very important. If an athlete neglects his daily nutritional needs during pre-competition it will interfere with concentration and the preparation process will be disrupted. The unsatisfactory results of training are a manifestation of prolonged nutrient deficiency and will interfere with performance (44).

If a vegetarian athlete, unable to meet the source of nutrition in a balanced manner, then use a daily supplement, then according to (44) states that, there will be no significant impact, because the use of supplements is still not optimal.

The results of another study, which showed the nutritional status of vegetarians according to BMI ( $\text{kg}/\text{m}^2$ ) showed no significant difference in BMI between users of the omnivore and lacto-ovo vegetarian diets and vegetarian. Not only BMI, including waist circumference did not show significant changes. All three categories are available (7).

Based Chattard et al (1999); Grober et al (2012); Brouns et al (1991); Mao IF (2001) in Nebl et al (2019), explained that vegetarians show the highest carbohydrate and fiber consumption figures, but do not meet the daily needs, including micronutrient intake will not be met through the fulfillment of supplements and especially vitamin D and cobalamin (7).

#### 4.6. Vegan Athletes Performance

Performance in athletes is a very broad term, in the context this article refers to strength, speed, endurance and strength. A study literature does not specify which type of vegetarian is the specific study, the aim is only to compare the physical performance of athletes of vegetarian and omnivorous mixed diets. The results of this study showed that there was no significant difference between the two athletes with a history of vegetarian and omnivorous mixed diets in their physical performance (10).

Physical training to improve specific components of fitness must be taken into account when considering nutritional needs, such as total energy and carbohydrate intakes. Nutrition supports training and good health, two factors that are essential to excellent performance.

Proper nutrition during the recovery period is essential for replenishing nutrient stores depleted during training, for example, muscle glycogen. Inadequate replenishment of energy, fluid, carbohydrates, proteins, and / or vitamins and minerals limits the potential for full recovery after training. Limited recovery can result in fatigue during the next training session, and consistent lack of nutritional replenishment can lead to chronic fatigue (45).

Most endurance athletes are interested in diets that positively affect exercise capacity and health, reduce body fat and promote the development of lean muscle mass [39]. Already thousands of years ago, the diet of athletes was seen as an important mean to increase performance. While in the past meat was seen as an irreplaceable performance-enhancing food today the trend is developing in the opposite direction: From partial exclusion (lacto-/ovo-/lacto-ovo-vegetarians) to the total elimination (veganism) of animal products from the diet. Since the prevalence of ambitious runners following plant-based diets is increasing (46), the impact of those diets with regard to athletes' performance and health is becoming of growing interest (47).

However, the evidence for this phenomenon to be transferred to improved physical performance in athletes is less clear. The aim of this study was to examine the evidence for the relationship between consumption of a vegetarian-based diet and improved physical performance by conducting a systematic literature review. Due to a vegetarian-based diet theoretically increasing muscle glycogen, cell alkalinity, and immunity while reducing oxidative stress, it was hypothesized that this diet may improve physical performance in athletes.

Anaerobic exercise produces lactic acid which is indicated by muscle fatigue. The results of the study stated that athletes with a history of vegetarianism with low protein intake showed no significant difference in the level of muscle fatigue when compared to athletes who consumed a mixed diet (48). However, when compared with the level of oxygen consumption, shown based on training, time, running distance there is no significant



difference in the vegetarian athlete. Craddock et al (2016) showed there is no difference in physical performance between vegetarian athletes or mixed diet at least muscular power, muscular strength, anaerobic and aerobic performance. It would be a recommendation in the future to meet vegetarian based-dietary, the association between a vegetarian diet and physical performance (10).

## 5. Conclusions

The vegetarian diet is widely applied by athletes with the aim of maintaining health, however inappropriate practices can result in deficiencies of nutrients such as protein, fatty acids, vitamin B12, vitamin D, iron and calcium and zinc. Although vegetarian practices does not necessarily affect athletes performance, since no significant difference found between vegetarian athletes and omnivore athletes performance. If deficiency occurs, it will affect the body's metabolism which can affect performance in athletes, so there is a role for supplementation for vegetarian athletes with nutritional deficiencies. Although in Indonesia, the practice of vegetarianism is not yet popular, it can be implemented with the aim of maintaining health and maintaining body weight.

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