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Can endurance athletes benefit from vegetarian diets?

Klementyna Dmowska, Franciszek Raszeja Memorial Municipal Hospital in Poznań, Mickiewicza 2 street, 60-834 Poznań

https://orcid.org/0009-0002-6343-3092

e-mail: dmowska.klementyna@gmail.com

Justyna Kaczanowska, Franciszek Raszeja Memorial Municipal Hospital in Poznań, Mickiewicza 2 street, 60-834 Poznań

https://orcid.org/0009-0006-6701-6105

e-mail: juskaczanowska@gmail.com

Emilia Żurowska, Franciszek Raszeja Memorial Municipal Hospital in Poznań, Mickiewicza 2 street, 60-834 Poznań

https://orcid.org/0009-0006-5952-1064

e-mail: emiliaazurowska@gmail.com

Abstract

The performance of an athlete is the result of a complex interplay of various factors, with diet representing a particularly crucial component. Nutritional profiles of vegetarian diets vary considerably from those of omnivorous diets. In our research, we propose that vegetarian diets may offer advantageous properties for endurance sportsmen. This review examines the distinctions between vegetarian and omnivorous diets and addresses these differences in the context of the nutritional requirements of athletes. The initial focus is on fundamental nutrients, including carbohydrates, proteins, and fats. Subsequently, the emphasis shifts to micronutrients. This analysis also encompasses the challenges and advantages associated with vegetarian diets. The subsequent section concerns the cardiovascular system, which is arguably the most crucial for endurance athletes. It examines the interaction between the cardiovascular system and other physiological factors, including dyslipidaemia, blood pressure and body weight. It also considers the impact of dietary modifications on these parameters and their influence on athletic performance. Finally, the recent research on the effects of a vegetarian diet on the performance of endurance athletes is presented. Despite a lack of conclusive evidence, recent research suggests that vegetarian diets may confer certain benefits, particularly in terms of endurance training. Although there is a paucity of rigorous research in this field, the existing evidence suggests that these dietary regimens may result in overall enhanced health and improved outcomes.

Keywords: athletic performance, blood pressure, body weight, cardiovascular system, dyslipidaemia, endurance athletes, vegetarian diet

Introduction

Meat used to be a symbol of prosperity and welfare. Until recently omnivorous diet was considered the healthiest and the most performance-enhancing type of dietary plan. However, we are observing a new trend toward meatless diets, such as vegetarian and vegan. In essence, vegetarianism is the practice of abstaining from meat, including red meat, poultry, fish and seafood.

There are a few different types of more specific vegetarian diets: lacto-vegetarian, ovo-vegetarian and lacto-ovo-vegetarian. Lacto-vegetarians consume dairy products but eschew eggs, ovo-vegetarians eat eggs but avoid dairy. Lacto-ovo-vegetarians ingest both, eggs and dairy. The most restrictive type of vegetarian diet is veganism. Vegans abstain from all animal-derived products, such as meat, fish, seafood, eggs, dairy and honey. In this review the term "vegetarian diets" will be used as a general term for all of the variants.

Recent studies show that vegetarian and vegan diets might have a positive impact on mortality in comparison to the omnivorous meal plan.[1–3] In recent times, there has been a growing interest in meatless diets among athletes. Such diets, when correctly balanced, are rich in vitamins, fibre and provide a lot of antioxidants and carbohydrates that are substantial for endurance runners. The energy expenditure associated with long-distance running is considerable, necessitating a rigorous dietary regimen for athletes to maintain energy homeostasis. Nonetheless, vegetarian diets are usually scarce in vitamin B12, creatine, carnitine and it is more difficult for vegetarians to follow a well-balanced diet with enough protein. However, if a balanced vegetarian diet is followed, it provides all essential amino-acids and sufficient protein consumption, unless an athlete requires abnormally high amounts of protein daily.[4] The majority of studies that have examined the performance of endurance athletes have not taken into account the dietary habits of the subjects. Furthermore, the majority of studies examining the influence of dietary habits on health status were conducted on non-athletic subjects. Consequently, there is a necessity for more comprehensive investigations specifically targeting athletes.

Therefore, the purpose of this study is to investigate the impact of lacto-ovo-vegetarian and vegan diets on the cardiovascular system and athletic performance in endurance athletes, in comparison with those following an omnivorous diet. The article is based on a review of the current literature available in databases: PubMed and Cochrane as of June 2024.

Diet requirements for endurance athletes

Maintenance of a healthy diet is crucial for all types of athletes. In addition to an adequate intake of carbohydrates, protein, and fat, athletes engaged in endurance sports must consume a substantial amount of vitamins, and micronutrients. It is therefore crucial for them

to identify an optimal diet that is not only nutritionally adequate but also easily sustainable within the context of their daily life. Sufficient energy intake is crucial, as it helps to maintain fitness and training goals. It varies significantly from person to person depending on factors such as: type of sport, age, gender, stress, medications and fitness prowess.[5]

Carbohydrates

Carbohydrates (CHO) are the essential nutrients as they are the main source of energy during exercise. They are one of the primary substrates of aerobic and anaerobic respiration, in which the energy is released. Sufficient CHO intake before, during and after prolonged activity is crucial as it helps to load and restore the glycogen supply that is stored in liver and muscles. Adequate fueling before can be linked with optimal performance during physical activity.[5,6]

According to the American College of Sports Medicine (ACSM) daily intake of CHO is varied depending on type of exercise and body type. In endurance training (1-3 hours per day) ACSM suggests eating 6–10 g of CHO per kilogram of body weight per day. It is recommended to increase the uptake of CHO before the competitions or high-intensity training. Furthermore, it is recommended that during prolonged periods of physical exertion, up to 90 grams of carbohydrates (CHO) be consumed per hour.[5]

Although overall energy intake is lower in vegetarian diets, the percentage of CHO consumed daily by vegetarians is higher than that of meat-eaters.[8] Vegetarian diet consists mostly of vegetables, fruits and grains - food that is rich in CHO, so accomplishing sufficient intake with a balanced diet is simple.[7] Still, it is crucial to stress the importance of consuming an adequate quantity of CHO to meet the energy demands. Plant-based products such as pasta, lentils, rice or fruits (bananas, raisins) are a valuable source of CHO for athletes.[9]

Protein

Protein represents the principal component of skeletal muscles and tendons. Adequate intake of protein plays a role in stimulating muscle protein synthesis (MPS), a process essential for ensuring the recovery of muscle tissue. The general recommendation for protein

intake in the adult population is 0.75 to 0.8 g per kilogram of body weight per day.[10] It is a prevailing conclusion that vegetarians consume less protein than meat-eaters. However, research conducted by Antonio et al. indicates that a plant-based diet can provide sufficient protein for vegetarians to meet their daily intake requirements. It should be noted, however, that athletes following a plant-based diet should consume 20%–40% more protein per day than the general population, in order to provide adequate sustenance.[12]

According to ACSM athletes should eat 1,2-2 g/kg/d of protein to ensure metabolic adaptation, repair and remodelling of a muscle.[5] Individual requirements for protein intake are variable, with the quantity necessary to support health and performance differing between people. Athletes who engage in both strength and endurance training may require more protein to support their training goals to meet their specific needs. [10,11]

Quality of protein-rich foods is important, as they can supply essential amino acids (EAA). Plant-based diets could be less digestible and rich in EAA, but according to West et al. consuming enough protein should be sufficient to ensure adequate EAA intake.[10] Good sources of plant-based protein are, for example, beans, legumes, and soybeans, while the availability and digestibility of protein can be improved by fermenting or processing them.[13]

Fat

Fat is a vital macronutrient which constitutes a source of energy and participates in numerous metabolic pathways. Other key roles of lipids include enabling the absorption of vitamins A, D, E and K, and serving as a component of cell membranes. However, its efficiency in providing energy is inferior to that of CHO.

In a healthy long-term diet, according to ACSM, at least 20% of energy intake should come from fats, with less than 10% derived from saturated fats.[5] Vegetable oils, nuts and avocados are well known and easily accessible sources of plant-based fat. Well-balanced diet should also comprise omega-3 polyunsaturated fatty acids (n-3 PUFA), nutrients that contribute to lessening the effects of inflammation that could be caused by exercise.[11,14] The percentage of energy coming from fats is higher in meat-eaters than that of people that follow plant-based diets. Still, vegetarians' energy intake consists of significantly more PUFA than meat-eaters'.[8]

A 2021 study[14] showed that both vegetarian and omnivorous endurance athletes consume insufficient amounts of PUFA. Having said that, according to West et al. supplementation could be an option, but it's not essential, as it doesn't seem to improve the performance of an endurance athlete.[10] Still, it is important to take into consideration individual preferences and requirements of an athlete. Traditional sources of omega-3 fatty acids consist of fish oils, but there are plant-based sources such as: algal oil, walnuts, flax seeds and chia seeds.[11,14]

In recent years, there has been a growing interest in ketogenic low-carbohydrate, high-fat (K-LCHF) diets in the field of endurance training. Although they are beneficial in terms of weight loss, the evidence is inconclusive regarding the efficacy of the diet in achieving athletic goals. The effectiveness of the diet varies depending on the type of exercise and its intensity. Overall, the benefits, such as cardiorespiratory fitness, weren't statistically noteworthy. [15–18]

Micronutrients

Micronutrients play a pivotal role in the body's metabolic processes, especially for individuals engaged in rigorous physical activities. These individuals must ensure that their micronutrient concentrations are maintained at optimal levels. Regular physical training sessions force human bodies to adapt in multiple ways. One of adaptations being increased red blood cells production or elevated levels of antioxidant enzymes.[19] Consequently, it is of vital importance to ascertain whether vegetarian diets have a discernible impact on micronutrient intake.

One of the most notable examples is iron, which is a component of haemoglobin and myoglobin. The recommended dietary allowance (RDA) by the National Food and Nutrition Institute in Poland is notably higher for pre-menopausal women (18 mg/day) than men (10 mg/day). Athletes following a lacto-ovo-vegetarian or vegan diet might be at risk of iron deficiency, as plant-based products contain only non-heme iron, which has lower bioavailability. As a consequence, it might be more difficult, especially for young female athletes, to ingest an adequate amount of iron. However, human body adapts and the absorption of iron increases and the risk of anemia between vegetarians is not higher than among people following omnivorous diet.[20]

According to other studies calcium, zinc and magnesium average levels were all within the normal range among omnivorous, lacto-ovo-vegetarians and vegans. Only zinc levels being more often low within vegans.[19]

Vitamin B12 (cobalamin), an essential nutrient, plays a role in the formation of red blood cells and is a cofactor in the synthesis of deoxyribonucleic acid (DNA). Moreover, it is implicated in the synthesis of myelin, which is indispensable for the optimal functioning of the nervous system. The European Food Safety Authority (ESFA) Panel on Dietetic Products, Nutrition, and Allergies assessed the Adequate Intake (AI) of cobalamin to 4 μg per day for adults, considering mean intakes between 4.2 and 8.6 μg/day in adults in European countries.[21] The vitamin is present in animal derived products and while there are some plant-derived sources of it (please refer to the table 1. for further details)[22], it is said that lacto-ovo-vegetarians and especially vegans are at risk of vitamin B12 deficiency. [23,24] However, a lot of products such as vegan milk substitutes are nowadays supplemented in B12, which makes it easier to ingest a sufficient amount. In a recent study conducted on vegetarian and vegan runners all groups had a satisfactory vitamin level.[19] Higher level of B12 was noted amongst supplement users. That study took into consideration eighty-one healthy omnivorous, lacto-ovo-vegetarians and vegans aged between 18 and 35 years, all of whom were recreational runners. The requirement was regular training sessions (2 to 5 times a week) for at least about 30-60 min.

A 2021 systematic review's [25] results indicated that intake and status of vitamin B12, vitamin D, iron, zinc, iodine, calcium were generally lower in plant-based dietary patterns compared to meat-eaters.

Micronutrient	Plant based sources
Iron	Grains, nuts, green vegetables, legumes
Calcium	Green vegetables, beans, seeds, nuts, fortified plant milks
Zinc	Beans, nuts, seeds, oats
B12	Fortified vegetarian products, supplements

Table 1. Plant based sources of certain micronutrients[7,21,25,26]

Cardiovascular system

Vascular diseases are a leading cause of death worldwide.[27] It is mostly due to a sedentary lifestyle, unhealthy diet patterns and smoking.[28] Ischaemic heart disease and stroke are the leading causes of death in the USA according to the World Health Organisation (WHO). While most people struggle to meet the recommended daily vegetable intake, vegetarians and vegans usually include more fresh, raw fruits and vegetables in their diets. This may have a cardio-protective effect, as it has been demonstrated to result in lower total cholesterol, low-density cholesterol, blood pressure and a lower body mass index (BMI).[2,29–31] It has been shown that vegetarian diet reduces risk of cardiovascular disease and that death rates due to ischemic heart disease. [2,32,33]

Atherosclerosis is a pathological process characterised by the accumulation of macrophages loaded with lipids within the arterial wall. This leads to the thickening and narrowing of the arteries,[34] which represents a significant risk factor for the development of cardiovascular disease. Endurance athletes, just like others, are not resistant to the development of arterial changes such as fatty streak.[35] These, in consequence, might lead to a fully mature atheromatous plaque. Active lifestyle is associated with lower risk of atherosclerosis, however, 2017 study[36] reported higher prevalence of atherosclerotic plaques between middle-aged and older male athletes in comparison with the same group age leading a sedentary lifestyle. 2009 study[37] included 102 healthy male marathon runners aged 50-72 years, who had completed at least 5 marathons during the previous 3 years. In this study, myocardial damage, as measured by myocardial distribution of late gadolinium enhancement (LGE) with cardiac magnetic resonance, was found in 12% of active runners, compared with 4% of age-matched control subjects. A different, 2014[38] observational study of 50 male marathon runners, who had run at least one marathon yearly for 25 consecutive years, found the runners to have increased total plaque volume, calcified plaque volume, and non-calcified plaque volume, compared with 23 sedentary male controls.

Randomised, controlled trials have demonstrated that a low-fat vegetarian diet, when combined with other lifestyle modifications, such as smoking cessation and moderate exercise, can lead to a reduction in the average diameter of coronary stenosis.[39,40] Given these findings, it is imperative for athletes to select an appropriate diet to prevent the formation of plaques and the subsequent development of cardiac events.

There are multiple factors that contribute to the state of a person's cardiovascular system, which in turn influences endurance capacity. The subsequent paragraphs will focus on some of the most important factors: dyslipidemia, blood pressure and body weight.

Dyslipidaemia

Dyslipidaemia is a key risk factor of developing cardiovascular diseases, as it plays a major role in the development of atherosclerosis.[34] Elevated blood concentrations of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG) are strongly related to cardiovascular diseases. In contrary, high levels of high-density lipoprotein cholesterol (HDL-C) are associated with lower risk of small artery occlusion.[41] Dyslipidemia is promoted by diets rich in saturated fat, it includes such products as meat and dairy - two key groups that are excluded by vegetarians (meat) and vegans (both meat and dairy). A 2015 systematic review and meta-analysis of randomised controlled trials (RCTs)[42] aimed to assess the overall effects of vegetarian diets on blood lipids (TC, LDL-C, HDL-C and TG). After selection 11 studies were included in quantitative synthesis - results suggest that vegetarian diets have a significant lowering effect on the concentrations of blood TC, LDL-C, HDL-C with no remarkable effect on TG. However, there are not enough studies based on athletes' population.

Blood pressure

Hypertension can be classified as either primary or secondary. Primary hypertension is defined as a condition that is not caused by any underlying pathological conditions, whereas secondary hypertension is defined as a condition that is caused by another pathological condition.[43] Elevated blood pressure has a direct impact on blood vessels, especially arteries. Blood hits walls of arteries with higher force, which in turn might damage endothelium, leading to excessive endothelial proliferation and vascular remodeling.[34,44] Should this pathological state persist, there is a possibility that it may result in the inflammation of the endothelium, which represents an additional risk factor in the formation of atherosclerotic plaques. Inflammation itself is a contribution to hypertension - it promotes vascular fibrosis, which leads to increased vascular resistance and stiffness.[45] The long term consequences of

uncontrolled hypertension may include coronary heart disease, cardiomegaly, heart attack, and a stroke.[45]

According to recent studies, vegetarian or fully plant-based diets result in lower diastolic and systolic blood pressure, partially because of weight loss.[46–49] As such, it might be of great use as a non-pharmaceutical way of managing blood pressure. Hypertension is among the most common chronic cardiovascular disorders in athletes.[50]

A 2015 study[51] conducted on elite male athletes with elevated BP has shown that they have significantly lower maximal oxygen consumption (VO2 max), ventilatory anaerobic threshold (VAT), and heart rate reserve (HRR). Maximum oxygen uptake (VO2max) is defined as the highest rate at which oxygen can be taken up and utilised by the body during severe exercise.[52] Heart rate reserve (HRR = HRmax − HRrest) is a way to prescribe and monitor exercise capacity.[53] During incremental exercise, a point is reached at which a subject's ventilation shows a non-linear steep increase and this is termed as ventilatory anaerobic threshold (VAT).[54] These reduced performance measures were present in the absence of structural or functional heart damage, allowing us to suspect that elevated BP itself can lead to decreased athletic performance.

Body weight

Excess body fat increases risk of atherosclerosis, but also directly impacts aerobic capacity. In a 2000 study[55], conducted on 129 children and 31 overweight women before and after weight loss, excess fat mass correlated with lower submaximal aerobic capacity, with no effect on VO2max. In contrast, a 2017 study[56], in which 30 male and 24 female healthy young adults participated, increased body fat was associated with decreased level of VO2max. The parameter is commonly used to indicate the cardiorespiratory fitness of an individual. An increase in VO2max is the most popular method of measuring a training effect. VO2max is one of the most important performance predictors for professional [57–59] as well as recreational[60] athletes. Therefore maintaining optimal body weight might directly result in higher VO2max and better performance.

There is strong evidence that plant based diets help reduce body mass [61–63] and vegetarians have lower BMI on average.[29,64–66] They not only reduce risk of cardiac events,

but also have a direct impact on a person's physical performance. As all types of vegetarian and vegan diets tend to include more fibre and less fat-rich products they simply make it easier for a person to lose excessive fat. In 2013 study [61] in which 291 participants, both men and women, with body mass index ⩾ 25 kg/m2 and/or previous diagnosis of type 2 diabetes were randomised to either follow a low-fat vegan diet, with weekly group support and work cafeteria options available, or make no diet changes for 18 weeks. Body weight, total cholesterol, triglycerides, blood pressure and glycated haemoglobin (HbA1C) were determined at 0 and 18 weeks. In this trial, a nutrition intervention has given significant improvements in body weight, plasma lipids and glycemic control among diabetics. Changes in these variables in the intervention group were greater than that in the control group, and were statistically and clinically significant. Systolic and diastolic blood pressures fell slightly in both groups, with no significant between-group differences. In a similar 2018 study [62] 75 overweight, otherwise healthy adult participants were randomly assigned to one of two groups; first - following a plant-based diet, and second - control diet. Participants in the control diet group were asked to follow their current diets - including animal products. Daily fat intake was 20-30 g. Participants were examined at baseline and 16 weeks. Significant reductions in body mass index and body weight were only observed in the vegan group. Similarly, fat mass and particularly visceral fat volume were reduced only in the vegan group.

Performance in endurance sports

A 2019 study[67] was meant to assess exercise capacity of female and male lacto-ovo-vegetarian and vegan recreational runners in comparison to omnivores. Participants were asked to perform an exercise test on a bicycle ergometer in order to determine maximal exercise capacity. Blood capillary samples were taken during the performed test to estimate glucose and lactate concentrations. Average age and BMI were not significantly different between all three groups. Results of this study showed no significant difference between maximum exercise capacity (estimated by maximum power related to body weight - PmaxBW) indicating that plant-based diets might be equal to omnivorous diet.

Another cross-sectional study conducted in 2016[68] on a group of lacto-ovo-vegetarians and omnivores used the Bruce protocol treadmill test to assess aerobic capacity within these groups. This test is used to estimate overall endurance of athletes, allowing

assessment of VO2 max. Results of that test showed that there was a significant discrepancy within these two groups, in favour of female vegetarians compared with female omnivores. However, absolute VO2 max did not differ notably between test groups. Second test performed during that study was a leg strength test conducted with a dynamometer. During the test there was no notable difference in leg extension peak torque. Results of this study show that plant-based endurance athletes might possibly have greater range of aerobic capacity (especially females) and equivalent strength.

The NURMI study[69] (Nutrition and Running High Mileage) was a cross-sectional (survey-based) investigation on recreational distance runners (10 km, half-marathon, marathon, and ultra-marathon distances) and was designed as a comparative study to investigate the prevalence of omnivores, vegetarians, and vegans in running events and to investigate possible differences in running performance between these three subgroups.

A first step of this study[70] aimed to identify potential associations among BMI, diet type and average best performance times of halt-marathon and marathon events for males and females. 3835 runners completed an online questionnaire, out of whose 2864 all-distance runners (median age: 37 years; 57% females, 83% had BMI within the norm) were included in inferential analyses and categorised into dietary subgroups according to self-reports: 994 vegans (34.7%), 598 vegetarians (20.9%), and 1272 omnivores (44.4%). Significant associations were identified between type of diet and best average time to finish: half-marathons in females where vegans ($p = 0.001$) took longer than omnivores, half-marathons in males where vegans ($p < 0.001$) and vegetarians ($p = 0.002$) took longer than omnivores, and marathons in males where vegans ($p < 0.001$) and vegetarians ($p = 0.043$) averaged slower than omnivores.

Second step[71] of NURMI study aimed to investigate certain training behaviours among recreational long-distance running athletes and the relationship of general diet types with best time race performance. The final participants ($n = 245$) included recreational long-distance runners following an omnivorous diet ($n = 109$), a vegetarian diet ($n = 45$) and a vegan diet ($n = 91$). No significant difference was found for best time half-marathon, marathon, and/or ultra-marathon race performance based on diet type ($p > 0.05$).

It remains unclear whether vegetarian diets are associated with enhanced endurance performance. Present results suggest that vegetarian diets are suitable for endurance runners.

Limitations

The most significant limitation of this study is the heterogeneity of the study group, which comprises individuals engaged in a wide variety of sports and at different ages. Additionally, there is considerable variability in dietary preferences, including both vegan and vegetarian diets. Ultimately, the performance of an athlete is the result of a complex interplay of numerous interrelated factors. Consequently, it is methodologically challenging to ascertain the precise impact of dietary modifications on athletic performance. Furthermore, the number of published studies on this topic is relatively limited.

Summary

In consideration of the aforementioned factors and constraints pertaining to our research, it is evident that vegetarian and vegan diets may offer potential benefits for athletes. The recent surge in interest in such diets, coupled with the prospect of increased research funding and further research, may contribute to a more comprehensive understanding of their potential advantages.

To date, only a limited number of scientific investigations have been conducted into the diets of endurance athletes. This implies that the evidence currently available is insufficient for us to conclude with certainty whether one or more of the diets under consideration might affect the performance outcomes of athletes. Nevertheless, our findings indicate that a vegetarian diet can readily satisfy the carbohydrate intake and availability requirements of competitive athletes. Furthermore, the essential amino acids intake can be considered sufficient for the nutritional requirements of athletes following such a dietary regimen. With regard to fats, the energy intake of those who consume plant-based foods contains a considerably higher proportion of polyunsaturated fatty acids than the intake of meat-eaters which may contribute to enhanced processes of tissue regeneration. A comparison of the intake and status of a number of essential vitamins (B12, D, iron, zinc, iodine and calcium) revealed that plant-based dietary patterns exhibited lower levels of intake compared to those who consumed meat. This highlights the potential need for consideration of supplementation.

It is evident that balanced plant-based diets confer beneficial effects on cardiovascular health. Such diets can help regulate lipid profile and blood pressure, whilst concurrently assisting in the prevention of formation of atherosclerotic plaques and reducing body weight. The extent to which their positive impact on exercise capacity in humans and their potential for accelerating the healing process remains to be elucidated.

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Author contributions

Conceptualization, K.D.; Resources, K.D., J.K., E.Ż.; Writing – Original Draft Preparation, K.D., J.K.; Writing – Review & Editing, K.D., J.K., E.Ż.; Supervision, K.D., J.K., E.Ż.

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Conflicts of interest

The authors declare no conflict of interest.

Data availability

Not applicable.

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