Dietas Sustentáveis e Performance Desportiva – Uma Revisão Sistemática

Sustainable Diets and Sports Performance – A Systematic Review

Gabriela Matos Silva

ORIENTADO POR: Prof. Doutora Maria Raquel Soares de Carvalho Roriz
COORIENTADO POR: Mestre Daniela Marques de Sousa

REVISÃO SISTEMÁTICA
1.º CICLO EM CIÊNCIAS DA NUTRIÇÃO | UNIDADE CURRICULAR ESTÁGIO
FACULDADE DE CIÊNCIAS DA NUTRIÇÃO E ALIMENTAÇÃO DA UNIVERSIDADE DO PORTO

TC

PORTO, 2024

Resumo

Nos últimos anos, a popularidade das dietas de base vegetal tem vindo a aumentar, tanto entre a população em geral, como nos atletas. Estas dietas têm não só um menor impacto ambiental mas também vários benefícios para a saúde. No entanto, ainda existem preocupações de que as dietas sustentáveis, como as de base vegetal, possam ser prejudiciais no rendimento desportivo devido a potenciais deficiências de determinados nutrientes. Nesta revisão sistemática, procuramos avaliar o impacto das dietas sustentáveis, como as dietas vegetariana, vegan e mediterrânica, na performance desportiva.

Foi realizada uma pesquisa bibliográfica nas bases de dados *PubMed, Scopus* e *Web of Science* (em abril de 2024) para identificar ensaios clínicos, estudos transversais ou de coorte que incluíssem atletas saudáveis ou indivíduos fisicamente ativos (18-65 anos), que adotassem uma dieta sustentável em comparação com uma dieta omnívora, ocidental ou de base animal. Foram incluídos 15 estudos, cujos resultados foram sintetizados qualitativamente. A avaliação do risco de viés foi realizada através da *Effective Public Health Practice Project-Quality Assessment Tool for Quantitative Studies*. Apenas cinco dos estudos incluídos mostraram um efeito positivo em pelo menos um *outcome* de performance desportiva. Nos restantes, não foram encontradas diferenças na performance desportiva entre grupos.

Estes resultados sugerem que estas dietas não são prejudiciais para o rendimento desportivo e que podem, eventualmente, ser benéficas para alguns *outcomes* estudados. No entanto, estas conclusões baseiam-se em evidência com elevado risco de viés, sendo necessária mais investigação de elevada qualidade e rigor científico no futuro.

Palavras-Chave: Dietas Sustentáveis, Dietas de base vegetal, Performance Desportiva.

Abstract

The popularity of plant-based diets has been on the rise in recent years, not only among the general public but also among athletes. These diets offer lower environmental impact and various health benefits. However, concerns persist that sustainable diets, such as plant-based diets, may be detrimental to exercise performance due to potential deficiencies in certain nutrients. In this systematic review, we seek to evaluate the effects of sustainable diets, including vegan, vegetarian, and Mediterranean diets, on sports performance.

We conducted a literature search on PubMed, Scopus, and Web of Science databases (on April, 2024) to identify clinical trials, cross-sectional or cohort studies that evaluated healthy athletes or physically active participants (18-65 years) following a sustainable diet compared to an omnivorous or western or animal-based diets. Fifteen studies were included. Quality assessment was conducted using the Effective Public Health Practice Project-Quality Assessment Tool for Quantitative Studies, and a qualitative synthesis was performed to summarize the extracted data. Only five studies showed a significant positive effect in at least one sports performance outcome. The remaining did not find any differences between diet groups.

Although our findings suggest that these diets do not prejudice sports performance and may be beneficial for some of these outcomes, these results rely on low-quality evidence, highlighting the need for more in-depth research.

Keywords: Sustainable Diets, Plant-Based Diets, Athletic Performance

List of abbreviations

1-RM – One Repetition Maximum

EPHPP - Effective Public Health Practice Project-Quality Assessment Tool for Quantitative Studies

FAO - Food and Agriculture Organization

LOV – Lacto-ovo-vegetarian Diet

MD – Mixed Diet

OMN – Omnivorous Diet

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

PROSPERO - Prospective Register of Systematic Reviews

UN – United Nations

VD – Vegetarian Diet

VEG – Vegan Diet

VO_2max – Maximum oxygen consumption

Summary

Resumo i

Abstract iii

List of abbreviations iv

Introduction 1

Methods 3

Search Strategy 3

Eligibility criteria 3

Selection process 4

Data extraction and Data Synthesis 5

Quality Assessment 5

Results 6

Vegan Diet 7

Vegetarian Diet 9

Mediterranean Diet 10

Risk of bias 10

Discussion 10

Limitations and Future Directions 14

Conclusion 15

References 16

Introduction

The United Nations (UN) estimates that world's human population will reach almost 10 billion by 2050[1]. According to the EAT-Lancet Commission, food is the most powerful tool for improving human health and ensuring environmental sustainability on Earth[2]. The real challenge relies on increasing food production while reducing its environmental impact. Food production has a large environmental impact accounting for 26% of global greenhouse gas emissions. Additionally, 50% of the world's habitable land and 70% of the global freshwater are used for agriculture[3]. Therefore, increasing adherence to sustainable diets could be one of the answers to this challenge.

Food and Agriculture Organization (FAO) defines a sustainable diet as one with production that has little environmental impact, is protective and respectful of biodiversity and ecosystems, and is nutritionally adequate, safe, healthy, culturally acceptable, and economically affordable[4].

Studies indicate that decreasing or abstaining from animal products, mainly red meat, helps lessen the food system's environmental impact. Vegetarian and vegan diets have been found to have a lower environmental impact compared to omnivorous diets, particularly in terms of climate change and land use[5, 6]. Furthermore, transitioning to a vegan diet can reduce total greenhouse gas emissions per capita by 4-20%, and up to 12% if transitioning to a vegetarian diet or a diet with a restricted intake of ruminant meat[7]. Reducing animal consumption and increasing intake of plant-based foods aligns with some governmental dietary guidelines for healthier and more sustainable diets[8].

Traditional Mediterranean diets[9], as well as vegetarian and vegan[10] have been proposed as sustainable dietary patterns.

In recent years, the popularity of these diets has been steadily increasing, not only among the general public but also among athletes. Even though the prevalence of vegetarian or vegan athletes remains unknown[11], surveys suggest that 8-20% of athletes follow a vegetarian diet and 1-35% follow a vegan diet[12, 13].

While it seems evident that it's possible to follow a dietary pattern that has a low environmental impact and is also consistent with good health, there are still common concerns that sustainable diets, like plant-based diets, may affect exercise performance[14] due to their lower availability of certain nutrients, especially certain vitamins and proteins, namely high biological protein sources[15, 16]. Athletes have higher energy and nutrient requirements compared to the general population[17]. Adhering to proper dietary guidelines is crucial for them to maintain overall health and optimize their performance capacity. However, research consistently indicates that athletes tend to consume protein in excess[18, 19], as they believe animal protein sources are needed for muscle recovery[20]. Others mistakenly believe that protein is muscle's main energy source[21].

Previous reviews have looked at how exclusively plant-based diets affect sports performance and have come to conflicting conclusions[22-24]. Some have shown improvements in aerobic performance[22], while others have found neither advantages nor disadvantages[23, 24]. However, as far as we know, there hasn't been a comprehensive systematic review regarding the effect of different sustainable diets on sports performance.

Thus, this study aimed to examine the role of sustainable diets on sports performance by systematically reviewing existing literature.

Methods

The present study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[25]. The protocol was previously registered at the International Prospective Register of Systematic Reviews (PROSPERO), under the registration number CRD42024554097.

Search Strategy

A systematic search was performed on the 9th of April using Pubmed, Scopus and Web of Science databases. The following terms and keywords were combined by Boolean logic operators (AND) and (OR): “Plant-based diet”, “Plant-based nutrition”, “vegetarian diet”, “vegetarian”, “vegan”, “macrobiotic”, “planetary health diet”, “EAT-Lancet diet”, “plant-forward”, “flexitarian”, “sustainable diet”, “Mediterranean diet”, “Mediterranean diet pattern”, “Mediterranean food pattern”, “sport”, “athlete”, “athletic”, “exercise”, “training” “physical activity”, “sports performance”, “athlete performance”, “athletic performance”, “exercise performance” “physical performance”, “endurance performance”, “training performance”, “aerobic performance”, “anaerobic performance”.
No date of publication or language restrictions were applied; however, the search query was performed only in English.

Eligibility criteria

Articles that met the following inclusion criteria were included: a) the study’s population consists of healthy adult athletes or healthy physically active adults (age 18-65 years), b) participants followed a sustainable diet such as a vegetarian,

vegan, plant-based, plant-forward (like the Mediterranean diet) or flexitarian diet, c) studies where the sustainable diet was compared to an omnivorous, western, mixed, animal-based or non-vegetarian diet, d) studies that evaluated objectively at least one physical performance outcome (aerobic performance, anaerobic performance, fatigue index, trial time, sprint velocity, maximum oxygen consumption, among others).

Studies were excluded if they: a) were not conducted in humans; b) were conducted on non-athletes or injured athletes, non-physically active individuals, pregnant women or individuals with chronic or acute diseases; c) were secondary design studies (such as systematic reviews, meta-analyses, narrative reviews), or guidelines, comments, conference abstracts, case series, case-reports, case-studies, letters to editors, among others; d) did not have a control group (sustainable diets were not compared to an omnivorous or western or mixed or animal-based diet), or evaluated isolated nutrients or foods; e) did not evaluate sports performance or only evaluate physiological outcomes (substrate oxidation, glycemia, and so on); f) did not evaluate the association between diet and sports performance outcomes, g) full text not available even after requesting the authors.

Selection process

One author performed the search strategy of the electronic databases. After conducting the initial search in each database, the references were exported to Endnote TM20 software, and duplicates were removed by both automatic and manual cleaning.

Initial screening was performed by one author, based on title and abstract. Articles identified as potentially eligible were fully examined by two authors

independently to ensure they met the eligibility criteria. Disagreements were resolved by consensus between the two authors after discussion. A third author's opinion was asked when doubts persisted.

Data Extraction and Data Synthesis

The included studies had their data extracted by two reviewers independently using a table developed in Microsoft® Word by the study team. A third reviewer oversaw the process of data extraction. Data on authors, publication year, country where the study was conducted, study design, sample characteristics and size, food-pattern descriptions, exercise protocol, sports performance outcome and main findings were extracted into a summary table. Due to substantial methodological heterogeneity in the included studies, we conducted a qualitative synthesis to summarize the extracted data and explore the association between sustainable diets and sports performance.

Quality assessment

To assess the quality of the included studies, we used the Effective Public Health Practice Project-Quality Assessment Tool for Quantitative Studies (EPHPP), a validated tool. This tool comprises six criteria: selection bias, study design, confounders, blinding, data collection method, and withdrawals/dropouts. According to the tool's guidelines, each criterion is rated as strong, moderate, or weak, and the overall assessment of each study is based on these ratings. If a study has no weak ratings, it is considered "strong"; one weak rating classifies a study as "moderate"; and two or more weak ratings classify a study as "weak". Two reviewers conducted the quality assessment of the included studies. Any

uncertainties were resolved through discussion between the reviewers, and if any doubt remained, a third author was consulted.

Results

As illustrated in the PRISMA flowchart (Figure 1), a total of 14791 references were retrieved from the database search. After duplicates were removed, 8674 references were left to be screened. Of the 79 studies eligible for full-text assessment, 16 records met the inclusion criteria. However, only 15 studies were included for qualitative analysis due to duplicated data. One study used a subsample[26] of another record found, so to prevent biased results[27], only the study with the higher sample size[28] was selected to be included in this review. The included articles varied in terms of study type, sustainable diet assessed, and evaluated sports performance outcomes. Of the included studies, eight were cross-sectional[28-35], four crossover trials[36-39], two were non-randomized clinical trials[40, 41], and only one was a randomized controlled trial[42].

In the qualitative analysis, a total of 446 subjects were included. Among them, 78 were athletes[28, 38] and 368 were either physically active or engaged in recreational activities[29-37, 39-43]. In the included studies, seven compared a vegan (VEG) diet with an omnivorous diet (OMN)[29, 30, 32, 34, 35, 40, 41], while one compared a VEG with a mixed diet (MD)[42]. Two studies compared a vegetarian diet (VD) with an OMN[28, 31], and two compared a lacto-ovo-vegetarian diet (LOV) with either the participants' normal diet[37] or a MD[38]. Another study compared an OMN, LOV, and VEG[33], and one study compared a whole food plant-based diet, a plant-based meat alternatives diet, and an animal-based diet[39]. Additionally, one study compared a Mediterranean diet to a Western diet[36].

Table 1 and Figure 1 from Appendix 1 offer a summary of the sports performance outcomes and main findings from the 15 included studies. Overall, five studies[28, 29, 31, 32, 36] showed a beneficial effect of following a sustainable diet in at least one sports performance outcome measured (four[28, 29, 32, 36] of them on aerobic outcomes). The remaining ten did not find any significant differences between diet groups. Additionally, none of the included studies suggested detrimental effects of these diets on sports performance.

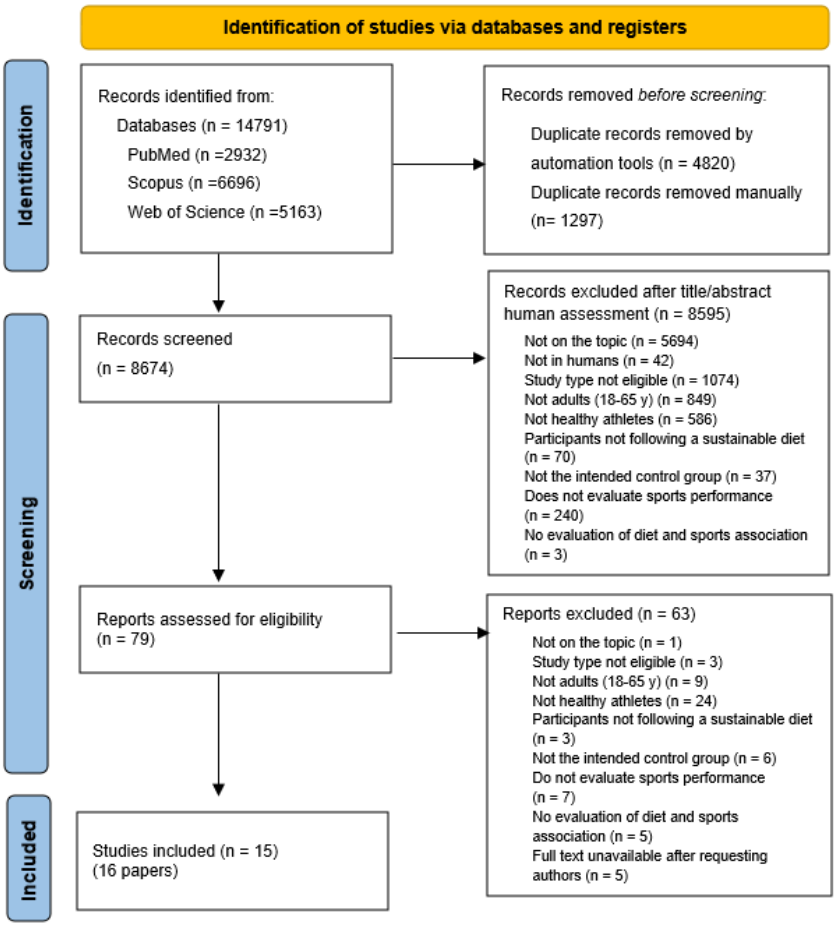


Figure 1. Study Flow Diagram adapted from PRISMA[25].

Vegan diet

Of the nine studies comparing vegan with either an omnivorous[29, 30, 32-35, 40, 41] or mixed diets[42], four examined strength outcomes. Isenman E. et al. found no significant differences in relative and absolute strength between vegans and

omnivores when measured using 1-Repetition Maximum (1-RM) on leg and bench press[41]. Similarly, Durkalec-Michalski K. et al. found no significant difference in endurance strength between vegans and participants following a MD, as evaluated by the maximum number of repetitions of squats and deadlifts at 70% of 1-RM in CrossFit-trained participants. Additionally, there were no differences in the results of a modified Fight Gone Bad test (FGBMod), a specific CrossFit workout, between both groups[42]. Another study showed that no significant differences were observed in strength increase during a 12-week resistance training intervention in young men following either a VEG or OMN diets[40]. In a recent cross-sectional study, researchers did not find significant differences in lower or upper muscle strength between vegans and omnivore women, but significantly longer submaximal endurance time to exhaustion and a higher estimated VO_2max compared to omnivores[29], which was verified also in Król W. et al involving amateur runners who followed a VEG diet, compared to omnivores[32]. Craddock J. et al found that, in aerobically trained participants, there were no differences in peak oxygen consumption (Peak VO_2) during an incremental ramp running test[30]. Similarly, in a cross-sectional study, no differences were observed in cardiorespiratory fitness between omnivorous and vegan recreationally active men[34]. Regarding anaerobic performance, a cross-sectional study with nine healthy omnivorous and nine healthy vegans found no significant differences in peak power, mean power, fatigue index and time to reach maximal power output[35]. Similarly, in another cross-sectional study of recreational runners, which included 24 vegans and 26 omnivores, no significant differences in maximum power output were found, neither related to body weight nor lean body mass[33].

Vegetarian Diet

All six studies evaluated the effect of vegetarian diets on aerobic performance outcomes[14, 31, 33, 37-39]. In a crossover study conducted by Raben et al., no differences in maximal oxygen uptake were observed among subjects after adopting a lacto-ovo-vegetarian diet for six weeks. The authors also observed that endurance performance until exhaustion remained unchanged[38]. Similarly, Hietavala E. et al. discovered that a low-protein vegetarian diet did not negatively impact time to exhaustion during submaximal and maximal cycling compared to the subjects' usual diet[37]. Lynch et al. found that vegetarian endurance athletes had significantly higher VO_2max compared to omnivores[28], but no differences in peak torque using leg extensions[28]. A cross-sectional study found that vegetarians and omnivores exhibited similar performance in terms of aerobic capacity and strength, as there were no discernible differences in maximal aerobic speed and isometric strength in the upper and lower limbs between the two groups. However, in this study, vegetarians displayed higher levels of relative strength and power. This was measured through a back squat exercise and a jump exercise with countermovement, respectively[31]. In a randomized crossover trial, Roberts et al. found that runners reported a similar VO_2max across all diets. Furthermore, the distance covered by runners during Cooper's 12-minute test was similar across all diets. When it came to resistance trainers, there were more push-ups and pull-ups performed on the animal diet compared to plant-based diets, but these discrepancies were not statistically significant. Additionally, there were no notable differences in total weight lifted during a chest press, leg press, and lat pull-down between the diets[39]. Nebl et al found no significant differences in

maximum power output, neither related to body weight nor lean body mass, between lacto-ovo-vegetarians and omnivores[33].

Mediterranean diet

Baker et al. conducted a randomized sequence crossover trial to compare the impact of a short-term Mediterranean diet to a Western diet on endurance and anaerobic performance[36]. It is important to note that, while following the Mediterranean diet, participants had lower consumption of sodium-rich foods, red meat and sugar products, along with a higher intake of whole fruits and vegetables, olive oil and fish, compared with the Western diet. The study found that participants achieved an increase of 6% in performance on a 5-kilometer run time when following the Mediterranean diet compared to the Western diet. However, no significant differences were observed in anaerobic exercise test results, including peak and mean power from the Wingate test, vertical jump and hand grip strength test.

Risk of bias

According to the EPHPP Quality Assessment tool, 14 of the total included studies were classified as weak, one as moderate, and none as strong (Table 2 from Appendix 1).

Discussion

The present systematic review intended to evaluate the role of sustainable diets on sports performance. Our results suggest that environmentally friendly diets do not prejudice sports performance and may be beneficial for aerobic performance. However, this data is predominantly based on cross-sectional studies, with small sample sizes, which are more prone to have higher risk of bias. These findings reinforce the need for more robust evidence regarding this topic.

Studies examining the impact of the vegan diet on anaerobic performance and strength outcomes were somewhat consistent since they did not find differences between the groups. Out of the four studies evaluating aerobic performance, two found higher values in maximum oxygen consumption[29, 32] and time to exhaustion[29] in vegans. Nevertheless, in both cases, the vegan group had a higher carbohydrate consumption than the omnivore group. Research has shown that greater carbohydrate intake may be associated with better endurance performance[44, 45], possibly due to higher glycogen storage[46]. Taking this into account, these results need to be cautiously interpreted and future research should ensure similar macronutrient distribution between studied diets.

Additionally, not all nine studies evaluating vegan diet controlled for performance-enhancing substances. Some studies asked participants to refrain from using any supplements[33, 35, 40, 42], one allowed them to continue their normal supplementation but had to switch to vegan products in vegan phase[41], and another only prohibited caffeine[34]. Not prohibiting supplements could lead to biased results since some substances, such as creatine, have been shown to enhance strength and resistance to fatigue[47-49], with greater performance improvement seen in subjects with lower intramuscular creatine levels, as usually happens in people following plant-based diets[50].

Regarding studies evaluating vegetarian diets, the ones that assessed aerobic performance did not find significant differences in maximum oxygen consumption[38, 39], distance covered[39], maximum aerobic speed[31], time to exhaustion at submaximal and maximal cycling[37], or endurance time until exhaustion[38], except for one study in which maximum oxygen consumption was

higher in the vegetarian group compared to the omnivorous group[28]. Additionally, studies evaluating strength outcomes found no differences between groups, except for one cross-sectional study that observed greater relative strength in vegetarians compared to omnivores. This study also found greater muscular power among vegetarians[31]. Despite having similar anthropometric measures to the omnivorous group, vegetarians showed a trend for lower weight, fat mass and body mass index, which could potentially have a positive influence on performance[51]. Another study evaluating anaerobic performance found no differences in maximal power output between groups[33]. Regarding performance-enhancing substances, only two studies controlled the use of supplements[33, 38], which is an important good practice as stated previously. This limitation was not observed in the studies carried out with a crossover mode, such as Hietavala et al.[37] and Roberts et al[39].

Concerning plant-forward diets, there was only one study that looked at the impact of the Mediterranean diet on sports performance. Baker et al. found improvements in endurance performance since 5-kilometer run time was shorter in the Mediterranean group, but no differences in anaerobic performance[36]. Due to the frequent consumption of whole fruit and vegetables, a higher intake of bioactive compounds, typical of the Mediterranean diet, may enhance nutrient and oxygen delivery to muscles through increased blood flow[52, 53]. This is one possible explanation for the contrasting results between aerobic and anaerobic outcomes.

Even though none of the included studies evaluated diets' sustainability, all vegetarian, vegan and Mediterranean diets, analyzed in this review, have been described in the literature as having a reduced environmental impact[9, 10], aligned

with FAO's definition of sustainable diets[4]. To the best of our knowledge, this is the first systematic review exploring the effects of sustainable diets on sports performance. However, some previous evidence on the impact of diet on sports performance has already been conducted. In a narrative review by Kaufman M. and colleagues on the impact of popular dietary trends on athletic performance, also including Mediterranean and plant-based diets (vegan and vegetarian), it was mentioned that this diet showed robust improvements in performance. However, two out of three studies used to corroborate this statement did not have a control group for diet. As for plant-based diets, the authors suggest a potential increase in VO_2max and submaximal endurance compared to omnivores, but without statistical significance[54]. A systematic literature review by Craddock and colleagues in 2016 compared physical performance between omnivores and vegetarians. The analysis of eight studies (seven trials and one cross-sectional study) concluded that there are no immediate differences in muscular power, muscular strength, or anaerobic and aerobic performance between vegetarians and omnivores[24]. Similarly, a literature review by Lynch H. and colleagues suggested that compared to an omnivorous diet, plant-based diets may not provide advantages or disadvantages in strength, anaerobic, or aerobic exercise performance[14]. Nevertheless, a meta-analysis performed by Damasceno Y. O. et al. stated that plant-based diets positively affected aerobic performance but did not modify strength and power performance[22]. It is important to highlight that all four included studies evaluating aerobic outcomes also met our inclusion criteria, but some methodological concerns need to be addressed, namely: the lack of standardization for carbohydrate consumption[29] and differences in

physical fitness levels between groups[28], or short diet intervention periods[37]. Another systematic review analyzing the relationship between vegetarian diets and sports performance found that vegetarian athletes had significantly higher values of oxygen consumption and maximal power, but no differences in strength-related parameters compared to omnivores[23].

According to the American Dietetic Association, vegetarian diets are nutritionally adequate for individuals at all life stages, including athletes[55]. Despite their well-known benefits in health and the absence of negative effects on sports performance debated in this review, when badly planned, some adverse effects of plant-based diets have been described, such as higher predisposition for macro and micronutrient deficiencies[56-59] and lower levels of creatine concentration in muscles[50]. For this reason, when transitioning to either a less restrictive vegetarian or a vegan diet, it is important to consider the ingestion adequacy of certain nutrients such as protein, omega-3, iron, zinc, iodine, calcium, vitamin D, and vitamin B12[55]. This highlights the importance of carefully considering these diets, preferably with the guidance of a registered nutritionist.

Limitations and future directions

Despite being the first review exploring the effects of sustainable diets on sports performance using a rigorous systematic approach, some limitations that may affect the results' interpretation should be addressed. All the experimental studies included had short-term interventions, ranging from 4 days to 16 weeks. In some of these, participants in the intervention group did not previously follow a vegetarian, vegan, or Mediterranean diet, but only adopted this dietary pattern for the duration of the study. It has been shown that vitamin B12 levels may decrease after 24-60 months of adopting a vegan diet[60]. Another study indicated

a decrease in muscle creatine levels after 3 months on a vegetarian diet[61]. Therefore, the short duration of the interventions may not be sufficient to observe changes from adopting these diets. In addition to the small sample size, no study had a representative sample. This limits the external validity of the studies and care should be taken when extrapolating the results. Furthermore, some of the studies did not adjust for possible confounders, such as performance-enhancing substances, like creatine and caffeine, or carbohydrate consumption. Also, some studies lacked information on the standardization of dietary intake or diet compliance, and one study did not provide enough detail about the control diet[37]. Lastly, as mentioned previously, since none of the studies evaluated diet sustainability, assumptions were made based on FAO's definition[4].

Further research is needed, preferably through randomized controlled trials with a larger number of participants and longer intervention periods. It is also important to ensure blinded assessors and standardized diets in both control and experimental groups. Even though none of the included studies were a cohort, this study design in athletes may also be important to assess the impact of sustainable diets on physical performance, since it does not change the natural occurrence of diet. In addition, researchers should consider using the Planetary Health Diet Index to evaluate the sustainability of the diets.

Conclusion

The potential impact of sustainable diets on performance is still a topic of debate. While there is still the need for more in-depth research regarding the potential benefits of sustainable diets on physical performance, our findings suggest that these diets do not decrease sports performance.

References

1. United Nations. Global issues: Our growing population. United Nations; 2021. [atualizado em: 1/8/2021; citado em: 10/6/2024]. Disponível em: https://www.un.org/en/global-issues/population.
2. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet. 2019; 393(10170):447-92.
3. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. Science. 2018; 360(6392):987-92.
4. Burlingame BA, Dernini S, Food Agriculture Organization of the United Nations Biodiversity International. Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. FAO; 2012.
5. Chai BC, van der Voort JR, Grofelnik K, Eliasdottir HG, Klöss I, Perez-Cueto FJA. Which Diet Has the Least Environmental Impact on Our Planet? A Systematic Review of Vegan, Vegetarian and Omnivorous Diets. Sustainability. 2019; 11(15):4110.
6. Aleksandrowicz L, Green R, Joy EJ, Smith P, Haines A. The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. PLoS One. 2016; 11(11):e0165797.
7. Hallström E, Carlsson-Kanyama A, Börjesson P. Environmental impact of dietary change: a systematic review. Journal of Cleaner Production. 2015; 91:1-11.
8. Fischer CG, Garnett T. Plates, pyramids, planet. Developments in national healthy and sustainable dietary guidelines: a state of play assessment. 2016.
9. Fresán U, Martínez-Gonzalez MA, Sabaté J, Bes-Rastrollo M. The Mediterranean diet, an environmentally friendly option: evidence from the Seguimiento Universidad de Navarra (SUN) cohort. Public Health Nutr. 2018; 21(8):1573-82.
10. Fresán U, Sabaté J. Vegetarian Diets: Planetary Health and Its Alignment with Human Health. Advances in Nutrition. 2019; 10:S380-S88.
11. Vegetarian and Vegan Diets for Athletic Training and Performance. 2018.
12. Pelly FE, Burkhart SJ. Dietary regimens of athletes competing at the Delhi 2010 Commonwealth Games. Int J Sport Nutr Exerc Metab. 2014; 24(1):28-36.
13. Wirnitzer K, Tanous D, Motevalli M, Wirnitzer G, Leitzmann C, Pichler R, et al. Prevalence of Female and Male Vegan and Non-Vegan Endurance Runners and the Potential Associations of Diet Type and BMI with Performance-Results from the NURMI Study (Step 1). Nutrients. 2022; 14(18)
14. Lynch H, Johnston C, Wharton C. Plant-Based Diets: Considerations for Environmental Impact, Protein Quality, and Exercise Performance. Nutrients. 2018; 10(12)
15. Larsson CL, Johansson GK. Dietary intake and nutritional status of young vegans and omnivores in Sweden. The American journal of clinical nutrition. 2002; 76(1):100-06.
16. Janelle KC, Barr SI. Nutrient intakes and eating behavior see of vegetarian and nonvegetarian women. Journal of the American Dietetic Association. 1995; 95(2):180-89.
17. Thomas DT, Erdman KA, Burke LM. Nutrition and athletic performance. Med Sci Sports Exerc. 2016; 48(3):543-68.

18. Spendlove J, Mitchell L, Gifford J, Hackett D, Slater G, Cobley S, et al. Dietary intake of competitive bodybuilders. Sports Medicine. 2015; 45:1041-63.
19. Lohman R, Carr A, Condo D. Nutritional intake in Australian football players: Sports nutrition knowledge and macronutrient and micronutrient intake. International journal of sport nutrition and exercise metabolism. 2019; 29(3):289-96.
20. Eck KM, Byrd-Bredbenner C. Food Choice Decisions of Collegiate Division I Athletes: A Qualitative Exploratory Study. Nutrients. 2021; 13(7):2322.
21. Jonnalagadda SS, Rosenbloom CA, Skinner R. Dietary practices, attitudes, and physiological status of collegiate freshman football players. The Journal of Strength & Conditioning Research. 2001; 15(4):507-13.
22. Damasceno YO, Leitao C, de Oliveira GM, Andrade FAB, Pereira AB, Viza RS, et al. Plant-based diets benefit aerobic performance and do not compromise strength/power performance: a systematic review and meta-analysis. British Journal of Nutrition. 2023
23. Hernández-Lougedo J, Maté-Muñoz JL, García-Fernández P, Úbeda-D'Ocasar E, Hervás-Pérez JP, Pedauyé-Rueda B. The Relationship between Vegetarian Diet and Sports Performance: A Systematic Review. Nutrients. 2023; 15(21)
24. Craddock JC, Probst YC, Peoples GE. Vegetarian and Omnivorous Nutrition - Comparing Physical Performance. Int J Sport Nutr Exerc Metab. 2016; 26(3):212-20.
25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021; 372:n71.
26. Ciuris C, Lynch HM, Wharton C, Johnston CS. A Comparison of Dietary Protein Digestibility, Based on DIAAS Scoring, in Vegetarian and Non-Vegetarian Athletes. Nutrients. 2019; 11(12)
27. Donato H, Donato M. [Stages for Undertaking a Systematic Review]. Acta Med Port. 2019; 32(3):227-35.
28. Lynch HM, Wharton CM, Johnston CS. Cardiorespiratory Fitness and Peak Torque Differences between Vegetarian and Omnivore Endurance Athletes: A Cross-Sectional Study. Nutrients. 2016; 8(11)
29. Boutros GH, Landry-Duval MA, Garzon M, Karelis AD. Is a vegan diet detrimental to endurance and muscle strength? Eur J Clin Nutr. 2020; 74(11):1550-55.
30. Craddock JC, Probst YC, Neale EP, Geraghty N, Peoples GE. A comparison of diet quality and cardiovascular and inflammatory responses between aerobically trained male adults following either a long-term vegan or omnivorous dietary pattern. Nutr Bull. 2023; 48(2):227-42.
31. de Souza AC, da Silva Brandão M, Oliveira DL, de Carvalho FG, Costa ML, Aragão-Santos JC, et al. Active Vegetarians Show Better Lower Limb Strength and Power than Active Omnivores. Int J Sports Med. 2022; 43(8):715-20.
32. Król W, Price S, Śliż D, Parol D, Konopka M, Mamcarz A, et al. A Vegan Athlete's Heart-Is It Different? Morphology and Function in Echocardiography. Diagnostics (Basel). 2020; 10(7)
33. Nebl J, Haufe S, Eigendorf J, Wasserfurth P, Tegtbur U, Hahn A. Exercise capacity of vegan, lacto-ovo-vegetarian and omnivorous recreational runners. J Int Soc Sports Nutr. 2019; 16(1):23.

34. Page J, Erskine RM, Hopkins ND. Skeletal muscle properties and vascular function do not differ between healthy, young vegan and omnivorous men. European Journal of Sport Science. 2022; 22(4):559-68.
35. Pfeiffer A, Tomazini F, Bertuzzi R, Lima-Silva AE. Sprint Interval Exercise Performance in Vegans. J Am Nutr Assoc. 2022; 41(4):399-406.
36. Baker ME, DeCesare KN, Johnson A, Kress KS, Inman CL, Weiss EP. Short-Term Mediterranean Diet Improves Endurance Exercise Performance: A Randomized-Sequence Crossover Trial. J Am Coll Nutr. 2019; 38(7):597-605.
37. Hietavala EM, Puurtinen R, Kainulainen H, Mero AA. Low-protein vegetarian diet does not have a short-term effect on blood acid-base status but raises oxygen consumption during submaximal cycling. J Int Soc Sports Nutr. 2012; 9(1):50.
38. Raben A, Kiens B, Richter EA, Rasmussen LB, Svenstrup B, Micic S, et al. Serum sex hormones and endurance performance after a lacto-ovo vegetarian and a mixed diet. Med Sci Sports Exerc. 1992; 24(11):1290-7.
39. Roberts AK, Busque V, Robinson JL, Landry MJ, Gardner CD. SWAP-MEAT Athlete (study with appetizing plant-food, meat eating alternatives trial) - investigating the impact of three different diets on recreational athletic performance: a randomized crossover trial. Nutr J. 2022; 21(1):69.
40. Hevia-Larraín V, Gualano B, Longobardi I, Gil S, Fernandes AL, Costa LAR, et al. High-Protein Plant-Based Diet Versus a Protein-Matched Omnivorous Diet to Support Resistance Training Adaptations: A Comparison Between Habitual Vegans and Omnivores. Sports Med. 2021; 51(6):1317-30.
41. Isenmann E, Eggers L, Havers T, Schalla J, Lesch A, Geisler S. Change to a Plant-Based Diet Has No Effect on Strength Performance in Trained Persons in the First 8 Weeks-A 16-Week Controlled Pilot Study. Int J Environ Res Public Health. 2023; 20(3)
42. Durkalec-Michalski K, Domagalski A, Główka N, Kamińska J, Szymczak D, Podgórski T. Effect of a Four-Week Vegan Diet on Performance, Training Efficiency and Blood Biochemical Indices in CrossFit-Trained Participants. Nutrients. 2022; 14(4)
43. Ficarra S, Di Raimondo D, Navarra GA, Izadi M, Amato A, Macaluso FP, et al. Effects of Mediterranean Diet Combined with CrossFit Training on Trained Adults' Performance and Body Composition. J Pers Med. 2022; 12(8)
44. Jacobs KA, Sherman WM. The efficacy of carbohydrate supplementation and chronic high-carbohydrate diets for improving endurance performance. International Journal of Sport Nutrition and Exercise Metabolism. 1999; 9(1):92-115.
45. Bangsbo J, Nørregaard L, Thorsøe F. The effect of carbohydrate diet on intermittent exercise performance. International Journal of Sports Medicine. 1992; 13(02):152-57.
46. Hearris MA, Hammond KM, Fell JM, Morton JP. Regulation of muscle glycogen metabolism during exercise: implications for endurance performance and training adaptations. Nutrients. 2018; 10(3):298.
47. Rawson ES, Stec MJ, Frederickson SJ, Miles MP. Low-dose creatine supplementation enhances fatigue resistance in the absence of weight gain. Nutrition. 2011; 27(4):451-55.
48. Kreider RB, Ferreira M, Wilson M, Grindstaff P, Plisk S, Reinardy J, et al. Effects of creatine supplementation on body composition, strength, and sprint performance. Medicine and science in sports and exercise. 1998; 30:73-82.

49. Lanhers C, Pereira B, Naughton G, Trousselard M, Lesage F-X, Dutheil F. Creatine supplementation and lower limb strength performance: a systematic review and meta-analyses. Sports Medicine. 2015; 45:1285-94.
50. Burke DG, Chilibeck PD, Parise G, Candow DG, Mahoney D, Tarnopolsky M. Effect of Creatine and Weight Training on Muscle Creatine and Performance in Vegetarians. Medicine & Science in Sports & Exercise. 2003; 35(11):1946-55.
51. Barbieri D, Zaccagni L, Babić V, Rakovac M, Mišigoj-Duraković M, Gualdi-Russo E. Body composition and size in sprint athletes. J Sports Med Phys Fitness. 2017; 57(9):1142-46.
52. Potì F, Santi D, Spaggiari G, Zimetti F, Zanotti I. Polyphenol Health Effects on Cardiovascular and Neurodegenerative Disorders: A Review and Meta-Analysis. Int J Mol Sci. 2019; 20(2)
53. Roelofs EJ, Smith-Ryan AE, Trexler ET, Hirsch KR, Mock MG. Effects of pomegranate extract on blood flow and vessel diameter after high-intensity exercise in young, healthy adults. Eur J Sport Sci. 2017; 17(3):317-25.
54. Kaufman M, Nguyen C, Shetty M, Oppezzo M, Barrack M, Fredericson M. Popular Dietary Trends' Impact on Athletic Performance: A Critical Analysis Review. Nutrients. 2023; 15(16)
55. Craig WJ, Mangels AR. Position of the American Dietetic Association: vegetarian diets. J Am Diet Assoc. 2009; 109(7):1266-82.
56. Appleby PN, Key TJ. The long-term health of vegetarians and vegans. Proc Nutr Soc. 2016; 75(3):287-93.
57. Clarys P, Deliens T, Huybrechts I, Deriemaeker P, Vanaelst B, De Keyzer W, et al. Comparison of Nutritional Quality of the Vegan, Vegetarian, Semi-Vegetarian, Pesco-Vegetarian and Omnivorous Diet. Nutrients. 2014; 6(3):1318-32.
58. Craig WJ. Health effects of vegan diets. The American journal of clinical nutrition. 2009; 89(5):1627S-33S.
59. Marsh K, Zeuschner C, Saunders A. Health implications of a vegetarian diet: a review. American Journal of Lifestyle Medicine. 2012; 6(3):250-67.
60. Mądry E, Lisowska A, Grebowiec P, Walkowiak J. The impact of vegan diet on B-12 status in healthy omnivores: five-year prospective study. Acta Sci Pol Technol Aliment. 2012; 11(2):209-12.
61. Blancquaert L, Baguet A, Bex T, Volkaert A, Everaert I, Delanghe J, et al. Changing to a vegetarian diet reduces the body creatine pool in omnivorous women, but appears not to affect carnitine and carnosine homeostasis: a randomised trial. British Journal of Nutrition. 2018; 119(7):759-70.

Appendix 1

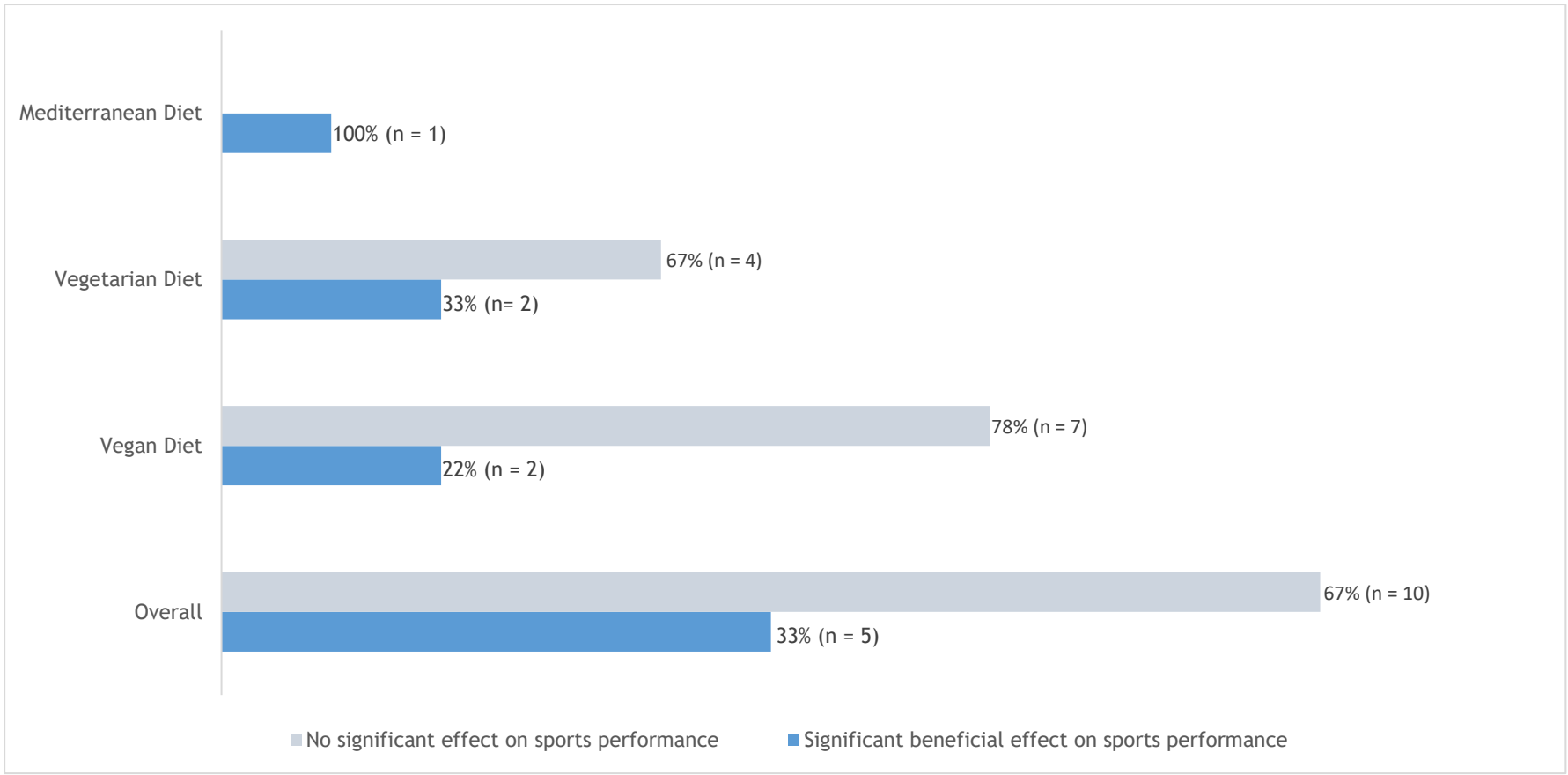


Figure 1. Overall results of each sustainable diet effect on sports performance.

Table 1. General characteristics of included studies.

Diet	Author, Publication Year	Country	Study Design	Final sample characteristics	Food pattern description	Exercise Protocol	Sports Performance Outcome	Main Findings
VEGAN DIET	Boutros G., 2020[29]	Canada	Cross-sectional	**Physically active women** (n = 56) OMN (n = 28) Age = 22.4 ± 4.1 y BMI = 22.3 ± 1.8 kg/m^2 VEG (n = 28) Age = 27.1 ± 3,7 y BMI = 21.7 ± 2.1 kg/m^2	**Omnivorous diet** CHO: 45.6% TEI PRO: 19.2% TEI FAT: 36.1% TEI **Vegan diet** CHO: 58.8% TEI PRO: 13.1% TEI FAT: 30.3% TEI	**Test 1: Cycle ergometer** (The exercise started at 50W and increased by 25W every 2 minutes until voluntary exhaustion) **Test 2: Cycle ergometer** (Intensity was set at 70% of their peak power output. Participants were asked to pedal until voluntary exhaustion) **Test 3: 1-RM** (leg press and chest press load increased until maximal effort was achieved)	**Estimated VO_2max** (ml/kg/min) OMN = 41.6 ± 4.6 VEG = 44.5 ± 5.2 **(p = 0.03)** **Time to exhaustion** (min) not adjusted for VO_2max OMN = 8.8 ± 3.0 VEG = 12.2 ± 5.7 **(p = 0.007)** **Time to exhaustion** (min) adjusted for VO_2max OMN = 9.3 ± 4.3 VEG = 11.7 ± 4.3 **(p = 0.049)** **Muscle strength - Leg Press** (kg/kg LBM) OMN = 2.5 ± 0.5 VEG = 2.4 ± 0.4 (p = 0.5) **Muscle Strength - Chest Press** (kg/kg LBM) OMN = 1.4 ± 0.3 VEG = 1.3 ± 0.2 (p = 0.06)	Estimated VO_2 was significantly higher in the vegan group compared with the omnivore group. Vegans had a higher time to exhaustion on a submaximal endurance test than omnivores, even when controlled for VO_2max. No significant differences between groups were noted for upper (chest press) and lower (leg press) body muscle strength.

Table 1. Cont.

	Craddock J., 2023[30]	Australia	Cross-sectional (pilot study)	**Aerobically trained males** (n = 20) OMN (n = 8) Age = 35.63 y (30.43 – 40.82) BMI = 24.67 kg/m^2 (23.03 – 26.27) VEG (n = 12) Age = 33.42y (29.57 – 37.26) BMI = 22.57 kg/m^2 (21.20 – 23.95)	**Omnivorous diet** CHO: 41.4% TEI PRO: 19.0% TEI FAT: 33.8% TEI **Vegan diet** CHO: 49.3% TEI PRO: 14.2% TEI FAT: 29.32% TEI	**Running Treadmill** (Participants walked for 5 minutes at 4 km/h, then the treadmill's speed was increased to 8 km/h with a 1% gradient. The speed was then raised by 1 km/h per minute until reaching a perceived exertion of 14 on a 15-point Borg scale. After that, the speed was maintained while increasing the gradient by 1% every minute until voluntary exhaustion.	**Absolute Peak oxygen consumption** (L/min): Peak VO_2 (OMN): 4.426 (4.007 – 4.845) Peak VO_2 (VEG): 4.241 (3.844 – 4.637) (p = 0.492) **Relative Peak Oxygen consumption** (ml/kg/min): Peak VO_2 (OMN): 55.73 (50.90 – 60.55) Peak VO_2 (VEG): 56.43 (51.98 – 60.89) (p = 0.816)	No differences were observed in the absolute or relative oxygen consumption between groups.
	Durkalec-Michalski K., 2022[42]	Poland	Randomized controlled trial	**Crossfit-trained participants** (n = 20) OMN (n = 10, ♀6 ♂4) Age = 31.0 ± 3.6 y VEG (n = 10, ♀6 ♂4) Age = 30.5 ± 3.0 y Participants BMI not available.	**Mixed diet** (4 weeks) CHO: 299.7 ± 48.1g PRO: 129.1 ± 14.9g FAT: 69.0 ± 19.0g **Vegan diet** (4 weeks) CHO: 275.2 ± 120.4g PRO: 110.0 ± 21.9g FAT: 98.9 ± 8.5g	**Squat and Deadlift at 70% 1-RM** (Maximum number of repetitions of classic barbel squats and classic deadlift with a load of 70% 1-RM)	**Endurance Strength** **Squat 70% 1-RM (reps)** (p > 0.05 between-groups) **Deadlift 70% 1-RM (reps)** (p > 0.05 between-groups)	There were no differences in endurance strength at 70% 1-RM HIFT-specific performance, and HIFT-training efficiency outcomes between groups.

Table 1. Cont.

						Modified HIFT-specific Fight Gone Bad Test (FGB_{Mod}) (Sequence of exercises in the following order: Wall-ball, Sumo Deadlift Higf Pull, Box Jumps, Push Press, Rowing on an ergometer. In each exercise, the objective was to perform as many technically correct repetitions as possible within 1 minute)	**Wall Ball (reps)** MD = 26.6 ± 3.9 VEG = 25.8 ± 7.9 (p = 0.776) **Sumo Deadlift High Pull (reps)** MD = 15.5 ± 7.1 VEG = 15.9 ± 6.1 (p = 0.821) **Box Jumps (reps)** MD = 23.5 ± 5.5 VEG = 23.0 ± 5.9 (p = 0.847) **Push Press (reps)** MD = 15.9 ± 5.7 VEG = 14.4 ± 5.9 (p = 0.571) **Rowing (kcal)** MD = 16.4 ± 3.6 VEG = 16.6 ± 5.9 (p = 1.000) **Total FGB_{Mod} Competition Time (seconds)** MD = 393.0 ± 20.2 VEG = 387.8 ± 27.8 (p = 0.850)	
	Isenmann E., 2023[41]	Germany	Non-Randomized Clinical Trial	**Physically Active** (n = 10, ♀7 ♂3) Age = 29.30 ± 9.26 y BMI = 23.25 ± 2.90 kg/m^2	**Omnivorous diet** (8 weeks) **Vegan Diet** (8 weeks)	**1-RM Test** (Participants performed a warm-up set, followed by 10 reps at 50% of the estimated 1-RM.	**Absolute Lower Limb Strength (kg)** Leg-press 1RM (OMN): 136.25 ± 64.32 Leg-press 1RM (VEG): 139.00 ± 67.77 p= 0.386	No significant group differences were detected in the absolute and relative strength capacity of the leg or bench press.

Table 1. Cont.

						After a 3-minute break, they did a set of 3 reps at 80% of the estimated 1-RM, followed by single reps of heavier weights until failure)	**Relative Lower Limb Strength** Leg-press 1RM (OMN): 1.91 ± 0.51 Leg-press 1RM (VEG): 1.98 ± 0.57 p = 0.171 **Absolute Upper Limb Strength (kg)** Bench-press 1RM (OMN): 53.25 ± 19.12 Bench-press 1RM (VEG): 52.75 ± 20.01 p= 0.673 **Relative Upper Limb Strength** Bench-press 1RM (OMN): 0.76 ± 0.20 Bench-press 1RM (VEG): 0.76 ± 0.20 p= 0.229	
	Hevia-Larraín V., 2021[40]	Brazil	Non-Randomized Clinical trial	**Physically active men** (n = 38) OMN (n = 19) Age = 26 ± 4 y BMI = 23.6 ± 2.3 kg/m^2 VEG (n = 19) Age = 26 ± 5 y BMI = 22.9 ± 2.3 kg/m^2	**PRE (Week 0)** **Omnivorous diet** CHO: 49% TEI PRO: 16% TEI FAT: 33% TEI **Vegan diet** CHO: 63% TEI PRO: 12% TEI FAT: 24% TEI **POST (Week 12)** **Omnivorous diet** CHO: 48% TEI PRO: 22% TEI	**Leg-press 1-RM** (Participants performed a warm-up set of 8 reps at 50% of estimated 1-RM, then a set of 3 reps at 70% of estimated 1-RM. Subsequent lifts are single reps of heavier weights until failure)	Pre-intervention **Leg-press 1RM** (kg) OMN: 261 ± 63 VEG: 258 ± 59 Post-intervention **Leg-press 1RM (kg)** OMN: 383 ± 74 VEG: 354 ± 81 (p = 0.11 changes between groups)	In 1-RM changes from pre to post-intervention, no differences between-group were detected.

Table 1. Cont.

					FAT: 32% TEI **Vegan diet** CHO: 58% TEI PRO: 21% TEI FAT: 24% TEI All diets were supplemented with soy or whey protein (for vegetarians and omnivores respectively), so that participants' protein intake reached 1.6g/kg/d			
	Król W., 2020[32]	Poland	Cross-sectional	**Runners (n= 52)** OMN (n = 30) Age = 30 ± 5 y BMI = 23 ± 1.3 kg/m^2 VEG (n = 22) Age = 32 ± 5 y BMI = 21.6 ± 2.1 kg/m^2 Participants' sex was not specified	**Omnivorous diet** CHO: 49.0% TEI PRO: 18.1% TEI FAT: 31.7% TEI **Vegan diet** CHO: 61.7% TEI PRO: 11.8% TEI FAT: 25.6% TEI	**Spiroergometric testing on a treadmill** (exercise protocol not specified)	**Maximum Oxygen consumption** (ml/kg/min): VO_2max (OMN): 50.1 ± 7.2 VO_2max (VEG): 54.0 ± 7.0 **(p < 0.05)** **Power max** (W) 324.2 ± 40.3 (OMN) 309.0 ± 36.0 (VEG) (p > 0.05) **Power AT (**W) 216.0 ± 49.0 (OMN) 197.0 ± 48.0 (VEG) (p > 0.05	Exercise capacity, measured by VO_2 max, was significantly higher in the vegan group. The peak power output reached in the treadmill test was similar in both groups.
	Page J., 2022[34]	United Kingdom	Cross-sectional	**Recreationally active men (n= 25)** OMN (n = 16) Age = 21 ± 1 y BMI = 24 ± 3 kg/m^2	**Omnivorous diet** CHO: 226 ± 64g PRO: 98 ± 30g FAT: 88.3 ± 38.4g	**Cycle ergometer** (Stage started with 95W, with an increase of 35W each 3 minutes until fatigue was reached)	**Absolute Maximum Oxygen consumption (VO_2max)** $EMD_{OMN,VEG}$ = 0.24 L/min 95% CI = −0.39; 0.87 BF_{01}= 2.392	There were no differences on cardiorespiratory fitness between groups.

Table 1. Cont.

				VEG (n = 9) Age = 24 ± 3 y BMI = 24 ± 4 kg/m^2	**Vegan diet** CHO: 245 ± 59g PRO: 63.2 ± 29.7g FAT: 37.6 ± 11.4g		**Relative Maximum Oxygen consumption (VO_2max)** $EMD_{OMN,VEG}$ = 4.81 mL/kg/min 95% CI = −3-77; 13.40 BF_{01}= 1.218	
	Pfeiffer A., 2021[35]	Brazil	Cross-sectional	**Physically active** (n = 18) OMN (n = 9, ♀5 ♂4) Age ♀ = 30.9 ± 5.4 y Age ♂ = 35.7 ± 8.1 y BMI ♀ = 22.2 ± 1.6 kg/m^2 BMI ♂ = 25.0 ± 1.4 kg/m^2 VEG (n = 27, ♀13 ♂14) Age ♀ = 32.2 ± 3.8 y Age ♂ = 31.1 ± 4.8 y BMI ♀ = 20.5 ± 1.6 kg/m^2 BMI ♂ = 2.,1 ± 2.8 kg/m^2	**Omnivorous diet** CHO: 41,6% TEI PRO: 22,3% TEI FAT: 36,0% TEI **Vegan diet** CHO: 60,6% TEI PRO: 20,8% TEI FAT: 18,6% TEI	**Cycle ergometer** (The test started with a 5-minute warm-up at 80 rpm against the cycle ergometer's resistance, followed by a 3-minute rest. Participants were then instructed to pedal "all-out" for 30 seconds against a resistance of 75 g/kg body mass)	**Peak Power** (F(1,16)=0.007; p=0.936; np^2 =0.001) **Mean power** (F(1,16)=0.071; p=0.794; np^2 =0.004) **Time to reach maximal power** (F(1,16)=0.002; p=0.962; np^2 =0.001) **Fatigue index** (F(1,16)=0.221; p=0.645; np^2 =0.014)	There were no differences between the vegans and the omnivores groups in either peak power, time to reach maximal power, mean power or fatigue index.
VEGETARIAN AND VEGAN DIET	Nebl J., 2019[33]	Germany	Cross-sectional	**Recreational runners** (n = 76) OMN (n = 26, ♀16 ♂10) LOV (n = 26, ♀16 ♂10) VEG (n = 24, ♀15 ♂9) Age = 27.4 ± 4.16y BMI = 21.9 ± 1.97 kg/m^2	**Omnivorous diet** CHO: 49.4% TEI PRO: 17.0% TEI FAT: 32.2% TEI **Ovo-lacto-vegetarian diet** CHO: 48.7% TEI PRO: 16.5% TEI FAT: 32.7% TEI **Vegan diet** CHO: 58.9% TEI PRO: 13.9% TEI FAT: 24.8% TEI	**Graded exercise test on a bicycle ergometer** (The test started with a 6-minute warm-up at 50W and then the workload was increased by 16.7W per minute until voluntary exhaustion)	**Maximum power** (W/kg BW) OMN: 4.15 ± 0.48 LOV: 4.20 ± 0.47 VEG: 4.16±0.55 (p = 0.917) **Maximum power output** (W/kg LBM) OMN: 5.29 ± 0.48 LOV: 5.39 ± 0.52 VEG: 5.26 ± 0.58 (p = 0.696)	There were no significant differences in P_{maxBW} or P_{maxLBM} between the three groups.

Table 1. Cont.

VEGETARIAN DIET	Hietvala E., 2012[37]	Finland	Randomized crossover trial	**Recreationally active men** (n= 9) Age = 23.5 ± 3.4 y BMI = 24.0 ± 1.8 kg/m^2	**Normal diet** (4 days) CHO: 49,8% TEI PRO: 17,6% TEI FAT: 28,1% TEI **Low protein vegetarian diet** (4 days) CHO: 58,7% TEI PRO: 10,1% TEI FAT: 24,7% TEI	**Cycle ergometer test** (Subjects cycled for 3 sets of 10 minutes at 40%, 60%, 80%, and 100% of their VO2max until exhaustion. The workload was increased by 50 or 75W in each stage.)	**Duration at 80% of VO_2max** (min): ND = 8.56 ± 1.87 LPVD = 8.85 ± 1.46 (p > 0.05) **Duration at 100% of VO_2max** (min): ND = 2.89 ± 1.91 LPVD = 1.81 ± 0.80 (p > 0.05)	There were no significant differences between groups on time until exhaustion on maximal and submaximal cycling.
	Lynch H., 2016[28]	United States of America	Cross-sectional	**Endurance athletes** (n = 70) OMN (n = 43, ♀17 ♂26) Age ♀ = 37.1 ± 8.7 y Age ♂ = 38.0 ± 10.0 y BMI ♀ = 23.5 ± 3.8 kg/m^2 BMI ♂ = 24.8 ± 2.6 kg/m^2 VD (n = 27, ♀13 ♂14) Age ♀ = 36.7 ± 7.7 y Age ♂ = 36.1 ± 10.2 y BMI ♀ = 21.8 ± 2.5 kg/m^2 BMI ♂ = 24.0 ± 4.4 kg/m^2	**Omnivorous diet*** CHO: 48% TEI PRO: 17% TEI FAT: 32% TEI **Vegetarian diet*** CHO: 53% TEI PRO: 12% TEI FAT: 32% TEI *This data only refers to 57 out of 70 participants.	**Graded exercise test on a treadmill** Bruce protocol (increased velocity and inclination every 3 minutes) **Leg extensions** on an isokinetic dynamometer (Three maximal efforts repetitions were performed at different speeds of 60, 180 and 240 degrees per second)	**Maximum oxygen uptake** Mean VO_2max (ml/kg/min): OMN ♀ = 47.1 ± 8.6 OMN ♂ = 55.7 ± 8.4 VD ♀ = 53.0 ± 6.9 VD ♂ = 62.6 ± 15.4 **(p = 0.011)** **Peak torque** (ft-lbs): OMN ♀ = 73.6 ± 18.6 OMN ♂ = 124.2 ± 24.5 VD ♀ = 65.5 ± 12.8 VD ♂ = 114.4 ± 26.2 (p = 0.104)	The vegetarian group had significantly higher VO_2max than the omnivorous group. Female vegetarians had 13% greater VO_2max than female omnivores. Among diet groups, no significant differences were observed in peak torque using leg extensions.

Table 1. Cont.

	Raben A., 1992[38]	Denmark	Non-randomized crossover Trial	**Endurance-trained male athletes** (n = 8) * Age = 22.5 y (21-28) Participants' BMI not available *4 cyclists, 1 runner, 1 rower, 2 mixed aerobic activities	**Ovo-lacto-vegetarian** diet **(6 weeks)** CHO: 57% TEI PRO: 15% TEI FAT: 28% TEI **Mixed diet (6 weeks)** CHO: 58% TEI PRO: 13% TEI FAT: 29% TEI ≈240 g/daily of meat or fish 4 weeks of the subject's habitual diets separated the two dietary periods.	**Graded ergometer cycle or treadmill exercise** (The test started at a heart rate of 100-120 beats/min and the workload increased by 10-15 beats/min every 15 minutes until exhaustion)	**Maximum oxygen uptake** Mean VO_2max at baseline: MD = 4.93 L/min (4.22-5.33) LOV = 4.83 L/min (3.87-5.55) Mean VO_2max after interventions: MD = 4.90 L/min (4.23-5,11) LOV = 4.79 L/min (4.04-5.17) ($p > 0.05$) **Endurance performance test** Median time at baseline: MD = 80.28 min (65.07-91.17) LOV = 79.13 min (55.67-90.07) ($p = 0.41$) Median time after interventions: MD = 75.50 min (64.45-97.02) LOV = 76.35 min (65.35-92.32) ($p = 0.25$)	No significant differences were observed in median VO_2max after the dietary periods. At the end of the 6-week dietary periods, endurance time was lower for six and higher for two of the eight subjects on the LOV compared with the MD. However, compared with week 0, no significant differences were observed.
	Roberts A., 2022[39]	United States of America	Randomized crossover trial	**Recreational runners (R)** (n = 11, ♀5 ♂6) Age = 26.2 ± 4.6 y BMI = 22.9 ± 2.3 kg/m^2 **Resistance trainers (RT)** (n = 11, ♀5 ♂6)	**Whole Food Plant-based diet (4 weeks)** CHO: 259 ± 67g PRO: 72 ± 13.2g FAT: 69 ± 19g)	**Cooper 12 min run** (Runners completed a 12-minute run at maximal effort, reporting total distance covered)	**R - Distance covered (m)** WFPB: 2768 ± 347 PBMA: 2789 ± 378 Animal: 2791 ± 391 WFPB – Animal: -23.4 (-107; 60.0) ($p = 0.54$) PBMA – Animal: -2.9 (-119; 113) ($p = 0.96$)	Runners covered a similar distance during Cooper's test on all diets.

Table 1. Cont.

				Age = 26.9 ± 4.3 y BMI = 23.3 ± 2.6 kg/m^2	**Plant-Based Meat Alternatives diet (4 weeks)** CHO: 222 ± 58g PRO: 85 ± 20g FAT: 77 ± 21g **Animal diet (4 weeks)** CHO: 205 ± 62g PRO: 107 ± 27g FAT: 75 ± 22g	**400m run** on a flat route with a Garmin GPS watch for the estimation of VO_2max	**R - Estimated VO2max (ml/kg/min)** WFPB: 50.1 ± 5.7 PBMA: 49.6 ± 5.4 Animal: 48.9 ± 5.9 WFPB – Animal: 1.2 (-0.9; 2.5) PBMA – Animal: 0.7 (-0.2; 1.7)	Runners reported a similar estimated VO_2 max on diets, with a non-significant trend for higher VO_2 max on plant-based diets compared to animal.
						3-rep maximum test (Resistance trainers recorded the maximum number of kg they lifted for three repetitions on machine-based exercises (chest press, leg press, lat pull-down) with 10-15 minutes rest between tests)	**RT - Muscular strength (kg)** WFPB: 298 ± 122 PBMA: 303 ± 123 Animal: 313 ± 144 WFPB – Animal: -2.7 (-5.8; 0.4) (p = 0.08) PBMA – Animal: -0.7 (-3.5; 2.2) (p = 0.62)	There were no significant differences in machine composite strength among diets.
						Maximum number of push-ups and pull-ups (Resistance trainers recorded the maximum number of push-ups and pull-ups completed before exhaustion)	**RT - Push-up (n):** WFPB: 34.9 ± 8.8 PBMA: 35.0 ± 7.6 Animal: 37.6 ± 14.8 WFPB – Animal: -2.7 (-8.0; 2.5) PBMA – Animal: -2.6 (-9.0; 3.8)	Resistance trainers completed more push-ups and pull-ups on Animal compared to plant-based diets, but these differences are not significant.

Table 1. Cont.

							RT - Pull-up (n): WFPB: 13.3 ± 3.2 PBMA: 13.5 ± 2.6 Animal: 13.9 ± 3.0 WFPB – Animal: -0.6 (-1.8; 0.5) PBMA – Animal: -0.5 (-1.6; 0.7)	
	Sousa A., 2022[31]	Brazil	Cross-sectional	**Physically active** (n = 58) OMN (n = 26, ♀12 ♂14) Age = 25.96 ± 4.97 y BMI = 23.65 ± 2.75 kg/m^2 VD (n = 32, ♀13 ♂19) Age = 25.28 ± 497 y BMI = 22.12 ± 3.06 kg/m^2	**Omnivorous diet** CHO: 49.27% TEI PRO: 18% TEI FAT: 15% TEI **Vegetarian diet** CHO 58.1% TEI PRO: 12% TEI FAT: 13% TEI	**Back squat exercise** (10 maximum repetitions on a guide bar) **Isometric strength tests** (Handgrip and Deadlift tests were performed three times with an interval of 60 seconds, the highest value was used for analysis) **Vertical jump** (Three attempts with 30 seconds recovery. The highest jump was	**Dynamic Strength** (kg) OMN = 61,85 ± 12,58 VD = 66,5 ± 15,3 (p = 0,218) ES = 0,36 **Relative Strength** OMN = 0,91 ± 0,12 VD = 1,03 ± 0,23 **(p = 0,020)** ES = 1,00 **Handgrip** (kgf) OMN = 70 ± 50 VD = 77 ± 29 (p = 0,516) ES = 0,14 **Deadlift** (kgf) OMN = 97 ± 50 VD = 89 ± 41 (p = 0,988) ES = 0,16 **Muscle Power -** Jump with countermovement (cm) OMN = 38,45 ± 8,92 VD = 43,77 ± 9,91 **(p = 0,038)** ES = 0,59	Vegetarians had greater relative strength and muscle power than omnivorous and were similar in all the other physical performance outcomes

Table 1. Cont.

						used for data analysis) **Treadmill incremental test** (Fixed inclination of 1%. Borg's scale was used to certify maximum effort)	**Maximum aerobic speed** (km/h) OMN = 11 ± 3 VD = 13,5 ± 2 (p = 0,463) ES = 0,83	
MEDITERRANEAN DIET	Baker M., 2019[36]	United States of America	Randomized crossover trial	**Physically active** (n = 11, ♀7 ♂4) Age = 28 ± 3 y BMI = 24.6 ± 3.2 kg/m^2	**Western diet** (4 days) CHO: 49% TEI PRO: 15% TEI FAT: 35% TEI **Mediterranean diet** (4 days) CHO: 42% TEI PRO: 19% TEI FAT: 43% TEI	**Treadmill** (Participants run for 5km on self-selected speed, without being able to see the treadmills' display) **Wingate anaerobic cycle test** (On a cycle ergometer with a resistance load equivalent to 75g/kg body weight, participants pedaled as hard and fast as possible for a full 30 seconds)	**Total 5km Run Time** (min) WD = 28.59 ± 3.21 MedD = 27.09 ± 3.55 (p = 0.030) **Peak power** (W) WD = 865 ± 54 MedD = 884 ± 43 (p = 0.663) **Relative Peak Power** (W/kg) WD = 12.4 ± 0.4 MedD = 12.9 ± 0.4 (p = 0.424) **Mean Power** (W) WD = 482 ± 43 MedD = 490 ± 35 (p = 0.665) **Relative Mean Power** (W/kg) WD = 7.0 ± 0.5 MedD = 7.1 ± 0.3 (p = 0.610)	The total run time for the 5km treadmill was 6% lower (faster) following the mediterranean diet compared to the western diet. Anaerobic exercise performance did not differ between the two dietary conditions.

Table 1. Cont.

						Handgrip (using a dynamometer, the best result of three attempts on each hand was recorded) **Vertical Jump Test** (Participants jumped from a standing position and touched the wall. The highest jump from three attempts was recorded)	**Muscle Strength** (kg) WD = 69.9 ± 3.4 MedD = 68.6 ± 4.4 (ρ = 0.633) **Muscle Strength** (kg/kg) WD = 0.97 ± 0.05 MedD = 0.96 ± 0.04 (ρ = 0.699) **Vertical Jump** (m) WD = 0.4 ± 0.03 MedD = 0.4 ± 0.03 (p = 0.190)	

BMI: Body Mass Index; LBM: Lean Body Mass; BW: Body Weight, TEI: Total Energy Intake; CHO: Carbohydrate; PRO: Protein; VEG: Vegans; OMN: Omnivorous; LOV: Lacto-ovo-vegetarian; MedD: Mediterranean Diet; WD: Western Diet; ND: Normal Diet; LPVD: Low-protein Vegetarian Diet; WFPB: Whole Food Plant-based Diet; PBMA: Plant-based Meat Alternative diet; 1-RM: One Repetition Maximum; VO_2max: Maximum oxygen consumption; P_{max}: Maximum Power; reps: repetitions; min: minutes; y: years; m: meters; km: kilometres; kg: kilograms; kgf: kilogram-force; ft-lbs: foot-pounds; W: Watts; ml: millilitres; L: Litres; h: hour; AT: measured at anaerobic threshold; B_F: Bayes Factor; ES: Effect size; EMD: Estimated mean differences; F: F-statistic test (ANOVA).

Table 2. Quality Assessment of included studies

Author, Year	Selection Bias	Study Design	Confounders	Blinding	Data Collection Methods	Withdrawals and Drop-Outs	Global Rating
Baker M., 2019[36]	WEAK	STRONG	STRONG	WEAK	MODERATE	STRONG	WEAK
Boutros G., 2020[29]	WEAK	WEAK	MODERATE	WEAK	MODERATE	NA	WEAK
Craddock J., 2023[30]	WEAK	WEAK	STRONG	WEAK	STRONG	NA	WEAK
Durkalec-Michalski K., 2022[42]	WEAK	STRONG	STRONG	WEAK	MODERATE	STRONG	WEAK
Hevia-Larrain V., 2021[40]	WEAK	STRONG	STRONG	MODERATE	MODERATE	STRONG	MODERATE
Hietvala E., 2012[37]	WEAK	STRONG	STRONG	WEAK	STRONG	NA	WEAK
Isenmann E., 2023[41]	WEAK	STRONG	STRONG	WEAK	MODERATE	MODERATE	WEAK
Król W., 2020[32]	WEAK	WEAK	WEAK	WEAK	MODERATE	NA	WEAK
Lynch H., 2016[28]	WEAK	WEAK	WEAK	WEAK	MODERATE	NA	WEAK
Nebl J., 2019[33]	WEAK	WEAK	STRONG	WEAK	MODERATE	NA	WEAK
Page J., 2022[34]	WEAK	WEAK	STRONG	WEAK	MODERATE	NA	WEAK
Pfeiffer A., 2021[35]	WEAK	WEAK	STRONG	WEAK	MODERATE	NA	WEAK

Table 2. Cont.

Raben A., 1992[38]	WEAK	STRONG	STRONG	WEAK	MODERATE	STRONG	WEAK
Roberts A., 2022[39]	WEAK	STRONG	STRONG	WEAK	MODERATE	STRONG	WEAK
Sousa A., 2022[31]	WEAK	WEAK	STRONG	WEAK	MODERATE	NA	WEAK

NA: Not applicable.

