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The Importance of Supplementation in Vegan and Vegetarian Diets for Adults

Justyna Wójtowicz

<https://orcid.org/0009-0006-6079-9637>

Stefan Wyszyński Provincial Specialist Hospital in Lublin, Aleja Krasnicka 100, 20-718 Lublin, Poland

wojtowicz.justtyna@gmail.com

Katarzyna Rudnicka

<https://orcid.org/0009-0005-6815-6276>

Stefan Wyszyński Provincial Specialist Hospital in Lublin, Aleja Kraśnicka 100, 20-718 Lublin, Poland

katarzyna.rudnicka95@gmail.com

Ilona Sajkiewicz

<https://orcid.org/0009-0007-5954-3594>

Stefan Wyszyński Provincial Specialist Hospital in Lublin, Aleja Kraśnicka 100, 20-718 Lublin, Poland

inasajka@gmail.com

Nadia Miga-Orczykowska

<https://orcid.org/0000-0002-0551-6159>

Stefan Wyszyński Provincial Specialist Hospital in Lublin, Aleja Kraśnicka 100, 20-718 Lublin, Poland

nadmig98@gmail.com

Paulina Lemieszek

<https://orcid.org/0009-0001-6648-7283>

Stefan Wyszyński Provincial Specialist Hospital in Lublin, Aleja Kraśnicka 100, 20-718 Lublin, Poland

paulina.lemieszek13@gmail.com

Ilona Jasiuk

<https://orcid.org/0009-0009-8544-3276>

Independent Public Clinical Hospital No. 1 in Lublin, Stanisława Staszica 16, 20-400 Lublin, Poland

ilona.jasiuk@gmail.com

Martyna Pustelniak

<https://orcid.org/0009-0000-5606-0385>

Provincial Combined Hospital in Kielce, Grunwaldzka 45, 25-736 Kielce, Poland

martyna.pustelniak@onet.pl

Katarzyna Krukar

<https://orcid.org/0009-0001-5544-8027>

Provincial Combined Hospital in Kielce, Grunwaldzka 45, 25-736 Kielce, Poland

kasiakrukar3@interia.pl

Ewa Łukaszewska

<https://orcid.org/0009-0000-6065-7213>

VOXEL NZOZ MCD, Paderewskiego 5, 37-100 Łańcut, Poland

lukaszewska.ewapaulina@gmail.com

Klaudia Kister

<https://orcid.org/0000-0003-2058-5395>

1st Clinic of Psychiatry, Psychotherapy and Early Intervention, Medical University of Lublin, 20-079 Lublin, Poland

klaudia2178@gmail.com

Abstract**Introduction and purpose**

Vegan and vegetarian diets are popular due to health, ethical, and ecological benefits, but they risk nutrient deficiencies. This article reviews research on supplementation to meet the nutritional needs of adults on these diets. It provides recommendations for different life stages, including pregnancy, aging, and physical activity, and highlights the risks of excessive or inadequate supplementation, stressing the need for personalized dietary approaches.

Material and method

A systematic review of the past decade's literature focused on peer-reviewed articles from databases like PubMed, Google Scholar, and Scopus. It included studies on adults adhering to vegan or vegetarian diets, evaluating supplementation's effects on nutrition and health. The review encompassed observational studies, interventions, meta-analyses, and systematic reviews, using keywords such as "vegan diet," "vegetarian diet," "supplementation," "nutrient deficiencies," and "adult health."

State of knowledge

Research shows that well-planned vegan or vegetarian diets can be healthy for adults, but often need supplementation to prevent nutrient deficiencies. Clinical studies confirm the efficacy of supplements. Specific groups, like pregnant and lactating women and those with regular physical activity, may need extra vitamins and minerals. Excessive supplementation poses health risks, so a personalized approach considering individual needs, health status, age, and lifestyle is crucial.

Conclusions

A well-balanced vegan or vegetarian diet, supported by appropriate supplementation, can be beneficial for the health of adults. A personalized approach to supplementation is essential, taking into account specific nutritional needs, pregnancy, health status, age, and lifestyle. Regular monitoring of nutritional status and adjusting supplementation to the body's current needs is crucial for maintaining optimal health.

Keywords: vegan diet, vegetarian diet, supplementation, nutrient deficiencies, adult health, pregnancy.

Introduction

Veganism and vegetarianism primarily stem from ethical, health-related, and ecological beliefs. Vegetarianism, as a practice of limiting or eliminating meat consumption, has ancient origins and is associated with various life philosophies and religious beliefs. Veganism, originating from the vegetarian movement, formally emerged in the 20th century with the goal of completely excluding animal-derived products from the diet, including meat, dairy, eggs, and their derivatives.[1]

There is a global trend of increasing popularity of vegetarian and vegan diets, especially in developed countries where there is growing awareness of health, ethical, and ecological issues.[2] Disparities between continents can be significant, with more developed regions such as Europe and North America showing higher percentages of the population adopting these diets compared to other regions.

In Poland, as in other countries of Central and Eastern Europe, the percentage of people following vegetarian and vegan diets has been relatively lower compared to Western countries, but there has been a noticeable upward trend. Studies indicate that younger generations and individuals residing in larger cities are more inclined to choose these diets.

The trend of adopting vegan and vegetarian diets also shows gender differences. Global analyses suggest that women are more likely to adhere to vegetarian and vegan diets than men, which may be related to greater interest in health and the environment.

Regarding vitamin deficiencies, differences between men and women adhering to vegan and vegetarian diets are significant. Recent studies emphasize that both sexes are at increased risk of vitamin B12 deficiency, which is predominantly found in animal-derived products. However, women, especially during pregnancy and lactation, are more susceptible to deficiencies in iron, folic acid, vitamin D, and omega-3 fatty acids (DHA). For men, zinc deficiency can be a significant challenge, as it is primarily found in larger quantities in meat and dairy products.

These differences stem from biological and physiological variations between sexes and specific nutritional requirements at different stages of life. Therefore, conscious dietary planning and appropriate supplementation are crucial for ensuring optimal health and well-being for both men and women, taking into account local dietary preferences and product availability. [3]

1. Material and method

1.1 Methodology of Systematic Literature Review

- **Literature Search:** A systematic review of the literature was conducted focusing on studies published in peer-reviewed scientific journals. Literature sources were searched in three main databases: PubMed, Google Scholar, and Scopus. These platforms provide access to a wide range of scientific publications covering various aspects of vegan and vegetarian diets and their impact on adult health.
- **Inclusion Criteria:** The review included studies conducted within the last ten years to ensure the relevance of the analyzed data. Inclusion criteria encompassed studies focusing on adults (aged 18 and older) adhering to vegan or vegetarian diets. Studies had to evaluate the impact of supplementation on nutritional status and health outcomes.
- **Types of Studies Analyzed:** The analysis included various types of studies, such as:
 - **Observational studies:** Assessing dietary patterns and their associations with health outcomes.
 - **Interventional studies:** Examining the effects of introducing supplementation to vegan or vegetarian diets.
 - **Meta-analyses and systematic reviews:** Synthesizing findings from multiple studies to derive more generalized conclusions regarding the effects of plant-based diets on adult health.
- **Keywords:** The following keywords were used during the search to precisely define the scope of the review: "vegan diet," "vegetarian diet," "supplementation," "nutrient deficiencies," and "adult health." These keywords were selected based on their relevance to studying the impact of vegan and vegetarian diets on nutritional status and adult health.

1.2 Advantages of Systematic Literature Review Methodology

A systematic literature review is considered a robust research method in medical science because:

- Provides comprehensive analysis: It encompasses a broad spectrum of scientific studies, enabling a thorough understanding of the subject matter.
- Reduces selection bias: Through stringent inclusion and exclusion criteria.
- Facilitates synthesis of results: Meta-analyses and systematic reviews allow for the integration of findings across multiple studies, enhancing the overall strength of evidence.

The outcomes of this systematic literature review serve as a robust basis for formulating recommendations concerning supplementation and planning balanced vegan and vegetarian diets for adults

2. State of knowledge

2.1 Deficiency and demand

Vitamin B12

Vitamin B12, also known as cobalamin, is an essential nutrient that plays a crucial role in numerous biological processes in the human body. It is vital for the production of red blood cells, the proper functioning of the nervous system, and DNA synthesis.[4] Vegans and vegetarians need to pay particular attention to their intake of vitamin B12, as their diet may lack natural sources of this nutrient.

Sources: Vitamin B12 is naturally found mainly in animal-derived products. While some plants and certain bacteria produce B12, these forms are biologically inactive for humans.

- **Sources of Vitamin B12:** Meat, fish, eggs, dairy products.
- **Fortified Sources of Vitamin B12:** Fortified cereals, soy milk, nutritional yeast, plant-based meat alternatives.

Symptoms of Deficiency: Vitamin B12 deficiency is a common issue among vegans and vegetarians because they exclude animal products, which are the primary sources of this vitamin. Symptoms of vitamin B12 deficiency can include: [5]

- Fatigue and weakness
- Concentration problems
- Mood disturbances
- Neurological symptoms such as tingling in the extremities, balance issues
- Megaloblastic anemia

Special Population Groups:

- **Pregnant and Breastfeeding Women:** Pregnant women have increased requirements for vitamin B12 to ensure the proper development of the fetus. B12 deficiency can lead to developmental defects and neurological problems in the child. Breastfeeding

women need to maintain adequate B12 levels as the vitamin passes into breast milk and is crucial for the infant's development.[6]

- **Elderly Individuals:** Older adults often have reduced ability to absorb B12 from food due to changes in the digestive system, increasing the risk of deficiency.
- **Physically Active Individuals:** Those with active lifestyles may have higher vitamin B12 requirements because it is needed for the production of red blood cells that transport oxygen to muscles.

Supplementation: Supplementation of vitamin B12 is often necessary for vegans and vegetarians to prevent deficiencies and their health complications. Key aspects of supplementation include:

- **Forms of Vitamin B12:** Cyanocobalamin and methylcobalamin are commonly used forms in supplements, both with high bioavailability.
- **Dosage:** Recommended supplementation doses for adult vegans are about 25-100 micrograms of cyanocobalamin daily or 1000 micrograms twice a week. For vegetarians who consume dairy products and eggs, lower doses may be sufficient.[7]
- **Absorption:** Vitamin B12 in supplements is highly bioavailable, although absorption may vary depending on the form administered and the individual's health status.

Why Supplementation is Crucial:

- **Prevention of Anemia:** Vitamin B12 is essential for the production of red blood cells. Its deficiency can lead to megaloblastic anemia, characterized by fatigue, weakness, and neurological issues.
- **Support for Nervous System:** B12 is crucial for the proper functioning of the nervous system. Deficiency can lead to neurological disorders such as neuropathy and cognitive impairments.
- **Support for Child Development:** Pregnant and breastfeeding women need higher levels of vitamin B12 to ensure the proper development of the fetus and the infant.

Medical Research: Many health professionals and dietitians emphasize the necessity of vitamin B12 supplementation for individuals on plant-based diets. Numerous scientific studies support these recommendations, highlighting various benefits and needs related to B12 supplementation for vegans and vegetarians.

- **Studies on Vitamin B12 Supplementation:**
 - **Effectiveness of Supplementation:** Meta-analyses have shown that B12 supplementation significantly increases blood B12 levels and improves hematological markers in individuals with deficiency. These studies underscore the effectiveness of B12 supplementation in preventing deficiencies in vegans and vegetarians.[8]
 - **Safety of Supplementation:** B12 supplementation is generally safe, but monitoring blood levels and adjusting the supplement dose according to medical advice is essential. Overdose symptoms are rare but can include acne and other skin issues.[9]

- **Impact on Neurological Functions:** Research has shown that B12 supplementation can improve neurological functions in deficient individuals, preventing severe complications such as neuropathy and cognitive disorders .
- **Requirements in Pregnant and Breastfeeding Women:** Studies on pregnant and breastfeeding women have demonstrated that B12 supplementation is critical for maintaining adequate levels in both mother and child, preventing severe health complications .

Practical Recommendations for Vegans and Vegetarians

1. **Regular Blood Tests:** Regular monitoring of blood B12 levels is crucial for assessing the body's stores and adjusting supplementation.
2. **Balanced Diet:** Consuming fortified plant-based products, such as fortified cereals, soy milk, and nutritional yeast, can help maintain adequate B12 levels.[10]
3. **Avoid Factors that Impair Absorption:** Avoiding factors that can impair B12 absorption, such as excessive alcohol consumption and certain medications.
4. **Consultation with a Dietitian:** Consulting a dietitian specializing in plant-based diets can help tailor a dietary plan and supplementation to individual needs.

Iron

Iron is an essential mineral that plays a crucial role in numerous biological functions in the human body. It is necessary for the production of hemoglobin, a protein in red blood cells that transports oxygen from the lungs to tissues. Iron is also important for proper immune function and energy production. Vegans and vegetarians need to pay special attention to their iron intake, as their diet may lack easily absorbable sources of this nutrient.

Sources: Iron exists in two forms: heme iron (found in animal products) and non-heme iron (found in plant-based products). Heme iron, present in meat, fish, and poultry, is more readily absorbed by the body. Non-heme iron, present in plants, has lower bioavailability, meaning the body absorbs it less efficiently.

- **Sources of Heme Iron:** Red meat, poultry, fish.
- **Sources of Non-Heme Iron:** Lentils, beans, tofu, spinach, quinoa, nuts, seeds, fortified cereals.[11]

Symptoms of Deficiency: Iron deficiency is a common issue among vegans and vegetarians, as they exclude animal products, the primary sources of easily absorbable iron, from their diet. Symptoms of iron deficiency can include:

- Fatigue and weakness
- Pallor
- Shortness of breath
- Dizziness
- Headaches
- Brittle nails
- Anemia

Special Populations

- **Pregnant and Lactating Women:** Pregnant women have increased iron requirements because they need it for both themselves and the developing fetus. Iron deficiency during pregnancy can lead to premature birth, low birth weight, and anemia. Lactating women also need to maintain adequate iron levels to support their baby's development and prevent their own deficiencies.[12]
- **Elderly Individuals:** Older adults may have reduced iron absorption from food and a higher risk of anemia, affecting their overall health and well-being.
- **Physically Active Individuals:** Those leading physically active lifestyles, especially with intense training, may require more iron to support red blood cell production and oxygen transport to muscles. Iron deficiency in athletes can lead to decreased physical performance, fatigue, and weakness.

Supplementation: Iron supplementation may be necessary for vegans and vegetarians to prevent deficiencies and associated health complications. Several key aspects of supplementation should be considered:

- **Form of Iron:** Non-heme iron supplements are well absorbed but may cause gastrointestinal issues. Heme iron supplements, while more bioavailable, are less common in plant-based diets.[13]
- **Dosage:** Recommended iron supplementation dosages vary based on individual needs, deficiency levels, and health status. Typical dosages range from 18 to 27 mg per day for adult women and from 8 to 11 mg for adult men.
- **Absorption:** Vitamin C can enhance the absorption of non-heme iron, so consuming vitamin C-rich foods, such as citrus fruits, bell peppers, or broccoli, alongside iron-rich meals is beneficial.

Importance of Supplementation

- **Prevention of Anemia:** Iron is essential for hemoglobin production, crucial for oxygen transport. Iron deficiency can lead to anemia, characterized by fatigue, weakness, pallor, and respiratory issues.
- **Immune System Support:** Iron is vital for proper immune function. Deficiency can increase susceptibility to infections.
- **Physical Performance Enhancement:** Adequate iron levels are important for maintaining physical performance and muscle recovery, especially for active individuals. Iron deficiency can lead to reduced physical performance and chronic fatigue.
- **Support for Child Development:** Pregnant and lactating women need more iron to ensure proper fetal and infant development.

Medical Reports: Many healthcare professionals and nutritionists underscore the critical importance of vitamin B12 supplementation for individuals adhering to plant-based diets. A

multitude of scientific research supports these guidelines, emphasizing the numerous benefits and essential requirements for B12 supplementation among vegans and vegetarians.

- **Research on Iron Supplementation:**

- **Efficacy of Supplementation:** Meta-analyses have shown that iron supplementation significantly increases hemoglobin and ferritin levels in individuals with iron deficiency, helping to prevent anemia. These studies underscore the effectiveness of iron supplementation in raising these markers in vegans and vegetarians.[13]
- **Safety of Supplementation:** While iron supplementation is generally safe, it can cause side effects such as gastrointestinal discomfort (e.g., constipation, diarrhea). Therefore, monitoring blood iron levels and adjusting supplement doses according to medical advice is important.[14]
- **Role of Vitamin C:** Studies have demonstrated that vitamin C significantly enhances the absorption of non-heme iron. Adding vitamin C-rich foods, such as citrus fruits, bell peppers, or broccoli, to meals can improve the bioavailability of iron from plant-based diets.
- **Iron Requirements for Athletes:** Research on vegan athletes has shown that iron supplementation can help maintain physical performance and prevent fatigue related to iron deficiency. Specifically, athletes may require higher iron doses due to increased needs associated with intensive training.

Practical Guidelines

- **Regular Blood Tests:** Monitoring blood iron levels, especially ferritin, is crucial for assessing iron stores and adjusting supplementation.
- **Balanced Diet:** Including plant-based sources of iron (e.g., lentils, beans, tofu) and vitamin C-rich foods can enhance iron absorption.
- **Avoiding Absorption Inhibitors:** Avoiding iron absorption inhibitors, such as coffee, tea, and calcium-rich foods, during iron-rich meals can also improve iron absorption.
- **Consulting a Dietitian:** Consulting a dietitian specializing in plant-based diets can help tailor dietary and supplementation plans to individual needs.

Omega-3 Fatty Acids

Omega-3 fatty acids, particularly EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), are essential components of the diet crucial for cardiovascular health, brain function, and overall physiological processes. Optimal sources of these fatty acids are predominantly associated with marine products, posing a challenge for individuals adhering to vegan and vegetarian diets.[15]

Sources: EPA and DHA naturally occur mainly in fatty fish such as salmon, mackerel, and herring, and in smaller amounts in certain marine plants such as algae. Plant oils (flaxseed oil, rapeseed oil, pumpkin seed oil) are typically rich in alpha-linolenic acid (ALA), a precursor to EPA and DHA omega-3 fatty acids. However, human metabolism has limited capacity to convert ALA into EPA and DHA, making plant oils less efficient sources of these fatty acids.[15]

Symptoms of Deficiency: Deficiency in omega-3 fatty acids EPA and DHA may manifest with various symptoms including:

- Increased risk of cardiovascular diseases
- Mood disorders, depression
- Impairments in learning and memory
- Increased risk of joint inflammation
- Skin problems such as dryness and scaling

Special Population Groups: Certain population groups such as pregnant and lactating women, as well as older individuals, may have increased requirements for omega-3 fatty acids due to their roles in fetal development, brain health, and cardiovascular function.[16]

Role of Supplementation: Supplementation with omega-3 fatty acids EPA and DHA is recommended for vegans and vegetarians to prevent deficiencies and support cardiovascular and neurological health. Key aspects of supplementation include:[15]

- Sources of supplementation: DHA supplements for plant-based diets are typically derived from microalgae, a natural source of DHA. Popular options include algae oil and capsule supplements.[15]
- Dosage of supplementation: Recommended doses of DHA supplements may vary depending on individual needs and lifestyle, but typical doses range from 200 to 500 mg of DHA daily. Some supplements may also contain EPA, which is beneficial for overall heart and brain health.[17]
- Monitoring and adjustment: Regular monitoring of omega-3 levels, especially DHA, in the blood is crucial to assess the effectiveness of supplementation and adjust doses accordingly.[15]

Medical Reports: Scientific research confirms the health benefits associated with supplementation of omega-3 fatty acids EPA and DHA in individuals following vegan and vegetarian diets. Meta-analyses and clinical studies demonstrate that adequate supplementation can reduce the risk of cardiovascular diseases, improve cognitive functions, and support mental health.

Vitamin D3

Vitamin D3, also known as cholecalciferol, is biosynthesized in the human epidermis upon exposure to ultraviolet B (UVB) radiation. However, this endogenous production is often inadequate due to insufficient sunlight exposure, particularly in regions with seasonal variations.

Vitamin D3 plays a pivotal role in calcium and phosphorus homeostasis, crucial for skeletal mineralization and overall bone health.

Sources: Naturally occurring sources of vitamin D3 predominantly include fatty fish (e.g., salmon, mackerel, herring), liver, egg yolks, and dairy products. Plant-derived sources of vitamin D2 (ergocalciferol) are less potent in elevating serum vitamin D levels due to inferior bioavailability and efficacy in converting to cholecalciferol.[18]

Symptoms of Deficiency: Deficiency in vitamin D3 can manifest clinically as osteomalacia in adults, characterized by impaired bone mineralization and increased fracture risk, and rickets in children, marked by skeletal deformities and growth retardation. Other consequences include musculoskeletal weakness, compromised immune function, and potentially elevated risk of chronic diseases.[38]

Special Population Groups: Certain demographic groups are particularly susceptible to vitamin D3 insufficiency, including older adults, individuals with darker skin pigmentation, those with limited sun exposure, and pregnant or lactating women. Vigilant monitoring of serum vitamin D levels and targeted supplementation are recommended to mitigate deficiency risks and optimize bone health.

Role of Supplementation: Supplementation with vitamin D3 is paramount for vegans and vegetarians to counterbalance potential dietary inadequacies and support musculoskeletal integrity and overall metabolic functions. Essential considerations for vitamin D3 supplementation encompass:

- **Sources:** Vitamin D3 supplements are typically sourced from animal products or synthesized for therapeutic use, ensuring sufficient cholecalciferol intake.[19]
- **Dosage:** Recommended supplementation doses vary based on individual serum levels, dietary intake, and health status, typically ranging from 800 to 2000 international units (IU) per day for adults.
- **Monitoring and Adjustment:** Regular assessment of serum 25-hydroxyvitamin D levels facilitates tailored supplementation regimens, optimizing therapeutic efficacy and minimizing potential adverse effects.

Medical Reports: Medical evidence underscores the critical role of vitamin D3 supplementation, particularly for individuals adhering to vegan and vegetarian diets where dietary sources of this vital nutrient may be limited.

Calcium

Calcium plays a crucial role in the diet of vegans and vegetarians, who may have limited access to traditional sources of this mineral such as dairy products and fish. While vegetarians can consume dairy, vegans completely eliminate animal-derived products, necessitating careful dietary planning.[36]

Sources: A vegan and vegetarian diet often relies on plant-based foods that may contain less bioavailable calcium compared to animal products. Key plant sources of calcium include:[20]

- Leafy green vegetables (e.g., kale, spinach, Swiss chard)
- Nuts and seeds (e.g., almonds, sesame seeds, chia seeds)
- Some types of beans (e.g., soybeans)
- Some legumes (e.g., peas)
- Some fortified products (e.g., plant-based beverages, juices)

The bioavailability of calcium from these sources can vary, making it challenging to maintain adequate calcium levels. Some plant components, such as phytic acid and oxalates, can negatively affect calcium absorption, further complicating effective dietary intake.

Symptoms of Deficiency: Calcium deficiency in vegans and vegetarians can lead to increased risk of osteoporosis, bone fractures, and muscle contractility disorders including the heart muscle.

Role of Supplementation: Calcium supplements are available in various forms, such as calcium carbonate and calcium citrate, each with different absorption rates. Regular monitoring of calcium levels and adjustment of supplementation are crucial to ensure bone health and overall well-being in individuals on plant-based diets.[21]

Medical Reports: Medical reports underscore that vegans and vegetarians may be susceptible to calcium deficiencies, particularly when their diet is not meticulously balanced for calcium. These deficiencies can contribute to weakened bones, increased risk of osteopenia and osteoporosis, and issues with the nervous and muscular systems.[22]

Folic acid

Folic acid, also known as folate or vitamin B9, plays a pivotal role in numerous biological processes, particularly in cellular proliferation and DNA synthesis. It is essential for the methylation of DNA, which is critical for maintaining cellular integrity and function, as well as for the production of red blood cells.[23]

Sources: Folic acid is naturally found in a variety of food sources accessible to vegans and vegetarians, including:

- Leafy green vegetables (spinach, kale, arugula)
- Legumes (e.g., lentils, beans, peas)
- Citrus fruits (e.g., oranges, grapefruits, lemons)
- Fortified grain products (e.g., breakfast cereals, bread)

While vegetarians can also obtain folic acid from dairy products, vegans rely exclusively on plant-based sources. The bioavailability of folic acid can be influenced by food preparation methods.[37]

Symptoms of deficiency: Folic acid deficiency can manifest in various health issues, such as:

- Megaloblastic anemia, characterized by fatigue and weakness
- Increased risk of neural tube defects in developing fetuses

- Cardiovascular complications

Role of supplementation: Supplementation with folic acid is often recommended, especially for pregnant women and individuals on vegan or vegetarian diets, who may have difficulty meeting their needs through diet alone. Regular supplementation can help prevent neural tube defects when initiated before conception and continued during early pregnancy.

Supplementation sources:

- Folic acid supplements are available in various formulations, including tablets, capsules, oral solutions, and chewable tablets. Dosage depends on individual health requirements and medical advice. Typically, adult daily recommendations range from 400 to 800 micrograms, with higher doses recommended for pregnant women.
- Natural and fortified sources: Choosing fortified foods rich in folic acid, such as fortified cereals, grain products, plant-based beverages, and vitamin supplements, can aid in ensuring adequate intake.

Medical reports: Medical studies underscore the importance of regular folic acid supplementation, particularly for individuals following vegan and vegetarian diets who may have limited access to natural sources of this essential nutrient.

Iodine

Iodine, an essential trace element, plays a pivotal role in thyroid hormone synthesis and function. Thyroid hormones, thyroxine (T4) and triiodothyronine (T3), are crucial for regulating metabolic processes, growth, and development throughout the body.

Sources: Natural dietary sources of iodine include:

- Seafood (e.g., cod, salmon, shrimp)
- Dairy products (e.g., milk, yogurt, cheese)
- Eggs
- Iodized salt and fortified foods

Vegan and vegetarian diets may be deficient in iodine due to the exclusion of seafood and limited intake of dairy products. Thus, vegetarians can rely on dairy sources, while vegans must depend on fortified foods.[24]

Symptoms of deficiency: Iodine deficiency can lead to various health complications, including:

- Goiter and thyroid nodules
- Thyroid hormone disorders such as hypothyroidism
- Cognitive impairment and intellectual developmental disorders, particularly in children (cretinism)

Role of supplementation: Supplementation with iodine is often necessary for individuals on vegan and vegetarian diets to prevent iodine deficiency. The recommended daily intake of iodine is approximately 150 micrograms for most adults, with higher doses recommended for pregnant and breastfeeding women.[25]

Iodine supplements are available in different formulations, including tablets, capsules, and iodine-fortified vitamin supplements. Regular monitoring of iodine levels in the blood is essential to adjust supplementation doses effectively.

Medical reports: Scientific research underscores the critical role of adequate iodine intake in maintaining optimal thyroid function and overall health.

Zinc

Zinc is an essential trace element critical for numerous biological processes in the human body, including protein synthesis, enzymatic reactions, immune function, and maintenance of cellular integrity. It plays a pivotal role in growth, development, wound healing, and skin health.

Sources: Dietary zinc is naturally found in various foods, such as:

- Red meat, poultry, fish
- Nuts and seeds, including pumpkin seeds, sunflower seeds, and cashews
- Whole grains like whole grain cereals and whole wheat bread
- Dairy products such as yogurt and cheese

For vegans and vegetarians who may have limited access to animal-derived products, careful dietary planning is essential to ensure adequate zinc intake. Opting for alternative sources like seeds, nuts, whole grains, and fortified products is crucial.[26]

Symptoms of Deficiency: Insufficient zinc levels can lead to various health complications, including:

- Impaired immune function
- Delayed wound healing and skin problems

Role of Supplementation: Zinc supplementation is often recommended for individuals on vegan and vegetarian diets, particularly if dietary zinc intake is inadequate. Recommended daily intake ranges from 8-11 mg for adult men and 8 mg for adult women, with increased needs during pregnancy and lactation.

Zinc supplements are available in various formulations, including tablets, capsules, liquid solutions, and lozenges. Regular monitoring of zinc levels in the blood and consultation with a healthcare provider are crucial to ensure effective supplementation.

Medical reports: Scientific research underscores the critical role of zinc in maintaining immune function, oxidative stress response, and enzymatic activities. Optimizing zinc intake through diet and supplementation can support overall health and mitigate the risk of conditions associated with zinc deficiency.

Magnesium

Magnesium is an essential mineral involved in numerous physiological processes crucial for human health. It plays a vital role in energy production, protein synthesis, muscle function, nerve transmission, and bone structure.[27]

Sources: Dietary sources of magnesium include:

- Nuts and seeds, such as almonds, sunflower seeds, and pumpkin seeds
- Whole grains, including brown rice, whole wheat bread, and oats
- Leafy green vegetables, like spinach, kale, and Swiss chard
- Legumes, such as beans, lentils, and chickpeas
- Dairy products like milk and yogurt
- Some seafood, such as salmon and mackerel

For individuals following vegan or vegetarian diets, which may limit intake of dairy and seafood, focusing on plant-based sources like nuts, seeds, whole grains, and leafy greens is crucial.

Symptoms of Deficiency: Inadequate magnesium levels can lead to various health issues, including:

- Muscle cramps and spasms
- Fatigue and weakness
- Irregular heartbeat and cardiovascular complications
- Impaired bone health and increased risk of osteoporosis

Role of Supplementation: Supplementation with magnesium may be recommended for individuals with dietary deficiencies or specific health conditions. Recommended daily intake varies by age and gender but generally ranges from 300 to 400 mg for adults.

Magnesium supplements are available in different forms, including magnesium citrate, magnesium oxide, and magnesium chloride. Monitoring magnesium levels in the blood and consulting with a healthcare provider are essential to determine the appropriate supplementation regimen.

Medical reports: Scientific studies emphasize magnesium's critical role in maintaining cardiovascular health, muscle function, and bone density. Optimizing magnesium intake through diet and supplementation can support overall well-being and mitigate the risk of conditions associated with magnesium deficiency.

Biotin

Biotin, also known as vitamin B7 or vitamin H, is an essential nutrient that plays a crucial role in the metabolism of fats, carbohydrates, and proteins. It is necessary for cell growth, fatty acid production, and maintaining the health of skin, hair, and nails.[28]

Sources: Biotin is naturally found in various foods, including:

- Eggs
- Liver

- Nuts, such as walnuts and cashews
- Whole grains, like wheat bran and oats
- Yeast
- Some vegetables, e.g., avocados and leafy greens

Additionally, gut bacteria can synthesize biotin, but the amount produced is insufficient to meet daily requirements.

Symptoms of deficiency: Biotin deficiency can lead to various health issues, such as:

- Skin problems, including dry skin and dermatitis
- Hair loss
- Changes in nail structure and health, such as brittleness and splitting

Role of supplementation: Supplementing with biotin is recommended in cases of dietary deficiency or specific health conditions that may lead to a deficiency. The recommended daily intake of biotin is around 30 micrograms for adults.

Biotin supplements are available in various forms, including tablets and capsules. It is important to regularly monitor health status and consult with a healthcare professional to adjust the appropriate supplementation dose.

Medical perspective: Research confirms the crucial role of biotin in maintaining the health of skin, hair, and nails, as well as in the body's energy metabolism. Optimizing biotin intake through a balanced diet and supplementation may support overall health and reduce skin, hair, and nail issues.

Vitamin A

Vitamin A, also known as retinol, plays a pivotal role in numerous physiological processes, crucial for vision, immune function, and epithelial integrity. It exists in two primary forms: retinoids derived from animal sources (preformed vitamin A) and provitamin A carotenoids from plant sources, such as beta-carotene.

Sources: Natural sources of vitamin A include:

- Liver, eggs, dairy products (retinoids)
- Green leafy vegetables, carrots, pumpkin, bell peppers (carotenoids)

Retinol, the form of vitamin A found in animal-derived products, is bioavailable and readily utilized compared to plant-derived carotenoids, which require enzymatic conversion within the body.

Deficiency Symptoms: Vitamin A deficiency can manifest as:

- Night blindness and other visual disturbances
- Impaired immune response
- Epithelial changes leading to dry skin and mucous membranes

Role of Supplementation: Supplementation with vitamin A may be indicated for vegans and vegetarians, particularly if their dietary intake of carotenoids is insufficient. Careful monitoring is essential due to the potential for toxicity with excessive intake of preformed vitamin A.[29]

Dosage: Recommended daily intake of vitamin A varies, typically around 900 micrograms (mcg) for men and 700 mcg for women, adjusted for individual health needs and dietary intake.

Monitoring Levels: Regular monitoring of serum vitamin A levels is critical to avoid hypervitaminosis A, which can lead to adverse health effects.

Medical Research and Reports: Scientific literature supports the role of adequate vitamin A intake from appropriate dietary sources in promoting ocular health, immune function, and epithelial integrity.

Vitamin K2

Vitamin K2, also known as menaquinone, plays a pivotal role in various biochemical processes within the body, particularly in the regulation of coagulation and maintenance of bone health. It exists as one of the two principal forms of vitamin K, alongside vitamin K1 (phyloquinone), distinguished by its chemical structure and metabolic pathways.[30]

Sources: Natural dietary sources of vitamin K2 encompass:

- Fermented foods such as cottage cheese (richest source), natto
- Meat, liver
- Less processed foods like eggs, butter
- Natto, a traditional Japanese fermented soybean dish, stands as one of the richest sources of vitamin K2.
- Certain fermented soy products like tempeh.
- Certain mushrooms, though their vitamin K2 content is generally lower.

Vitamin K2 is synthesized endogenously by intestinal bacteria, yet dietary intake remains essential. For vegans and vegetarians, who exclude animal-derived products, prudent selection of vitamin K2 sources is critical to sustain bone health and overall physiological function.

Physiological Role: Vitamin K2 facilitates the activation of calcium-binding proteins (e.g., osteocalcin), pivotal for regulating calcium deposition in bone tissue, thereby promoting bone mineralization and mitigating the risk of osteoporosis.

Deficiency: Inadequate vitamin K2 levels can lead to impaired coagulation and compromised bone health, elevating the susceptibility to fractures and osteopenia.

Supplementation: Supplementation with vitamin K2 is typically recommended in MK-7 (menaquinone-7) form, renowned for its superior bioavailability and sustained activity within the body. Dosage should be tailored to individual health requirements and medical guidance, commonly ranging from 100 to 200 micrograms daily.

Clinical Insights: Considering vitamin K2 supplementation is advisable for individuals adhering to vegan and vegetarian diets, especially in instances where natural dietary sources are limited.

Selenium

Selenium is an essential trace element that plays a critical role in various biological processes, including antioxidant defense, thyroid hormone metabolism, and immune function. It exists in organic and inorganic forms, with selenomethionine and selenocysteine being the primary organic forms found in food sources.[31]

Sources: Natural dietary sources of selenium include:

- Brazil nuts, seafood, and organ meats (rich sources)
- Whole grains, dairy products, and eggs (moderate sources)
- Vegetables and fruits (lower sources)

Role in the Body: Selenium is integral to the function of antioxidant enzymes such as glutathione peroxidases and thioredoxin reductases, which protect cells from oxidative damage. It also regulates thyroid hormone metabolism and supports immune responses.

Deficiency Symptoms: A deficiency in selenium can lead to health issues such as:

- Weak immune function
- Impaired thyroid function
- Cognitive decline

Supplementation: Supplementation with selenium may be recommended for individuals with low dietary intake or specific health conditions that affect selenium absorption. However, excessive intake can lead to toxicity, so supplementation should be monitored carefully.

Dosage: The recommended daily intake of selenium varies but generally ranges from 55 to 200 micrograms per day for adults, depending on age, sex, and health status.

Medical Insights: Research highlights selenium's role in reducing oxidative stress and supporting immune health. Balanced intake through diet or supplementation can contribute to overall well-being.

2.2 Overdosing on supplements[32]

Vitamin B12: Overdosing on vitamin B12 is uncommon due to its high tolerability. However, it can rarely lead to dermatological allergic reactions or skin manifestations. Prolonged use of high doses should be avoided without medical supervision.

Iron: Iron overdose can result in iron poisoning, particularly hazardous in pediatric populations. Symptoms include nausea, vomiting, diarrhea, and potentially severe organ damage. Non-indicated, chronic high-dose iron intake poses significant risks.

Zinc: Excess zinc intake may cause gastrointestinal symptoms such as nausea, vomiting, diarrhea, and metabolic disturbances. Chronic high-dose zinc consumption can impair immune function and interfere with the absorption of other micronutrients like copper.

Selenium: Selenium overdose can lead to selenosis, characterized by toxic symptoms including brittle hair and nails, fatigue, vertigo, and in severe cases, organ toxicity.

Omega-3 Fatty Acids: Overconsumption of omega-3 fatty acids can induce bleeding tendencies, gastrointestinal disorders, and immune suppression. Prolonged use of very high doses may also impact coagulation pathways.

Iodine: Excessive iodine intake can disrupt thyroid function, resulting in hyperthyroid symptoms such as tremors, tachycardia, diaphoresis, and dysregulation of body weight.

Vitamin K2: Overdosing on vitamin K2 is rare, yet excessive doses may perturb coagulation processes, especially in patients receiving anticoagulant therapy. However, documented cases of toxicity associated with vitamin K2 are uncommon.

Biotin: Biotin overdose is infrequent but possible, potentially leading to impaired absorption of other vitamins, notably vitamin B5, which could adversely affect integumentary health.

Magnesium: Magnesium overdose is rare but can precipitate diarrhea, nausea, vomiting, and muscular weakness. Long-term consumption of large magnesium doses may disturb electrolyte balance.

Folic Acid: Supraphysiological folic acid intake is uncommonly associated with masking symptoms of vitamin B12 deficiency. In individuals with renal impairment, elevated folic acid levels can pose health risks.

Calcium: Calcium supplementation in excess can predispose individuals to nephrolithiasis, heightened cardiovascular morbidity, and disruption of micronutrient absorption, including iron and zinc.

Conclusions

Supplementation as a Crucial Element of Vegan and Vegetarian Diets. Adequate supplementation not only prevents nutrient deficiencies but also contributes to long-term health benefits. Studies indicate that individuals adhering to plant-based diets and using supplements exhibit superior health outcomes in terms of bone health, cognitive function, and cardiovascular health compared to non-supplementing counterparts.[33]

Recommendations

Regular Monitoring: Individuals on vegan and vegetarian diets should undergo regular assessment of key nutrient levels, including vitamin B12, vitamin D, omega-3 fatty acids, iron, and zinc.[34]

Consultation with a Registered Dietitian: Collaborating with a qualified dietitian can aid in customizing dietary plans and supplementation protocols based on individual requirements.[36]

Education: Educating individuals on the significance of supplementation and accessible sources of nutrients is pivotal for the health of individuals on plant-based diets.

Summary

Vegan and vegetarian diets can be healthful and balanced with meticulous supplementation management.[33] Consistent supplementation of critical nutrients such as vitamin B12, vitamin D, omega-3 fatty acids, iron, and zinc is indispensable for maintaining optimal adult health while following these dietary choices. Engaging with healthcare professionals and promoting awareness about proper nutrition can mitigate deficiencies and ensure enduring health benefits.[35]

Disclosure

Authors' contributions

Conceptualization: Justyna Wójtowicz, Ilona Jasiuk

Methodology: Paulina Lemieszek, Nadia Miga-Orczykowska,

Software: Justyna Wójtowicz, Ewa Łukaszewska, Katarzyna Krukar

Check: Martyna Pustelniak, Katarzyna Rudnicka, Ilona Sajkiewicz

Formal analysis: Justyna Wójtowicz, Nadia Miga-Orczykowska

Investigation: Katarzyna Rudnicka, Martyna Pustelniak, Klaudia Kister

Resources: Ilona Sajkiewicz, Paulina Lemieszek, Ilona Jasiuk

Data curation: Martyna Pustelniak, Ilona Jasiuk, Justyna Wójtowicz

Writing - rough preparation: Katarzyna Krukar, Klaudia Kister, Justyna Wójtowicz

Writing - review and editing: Ewa Łukaszewska, Ilona Jasiuk, Ilona Sajkiewicz

Visualization: Nadia Miga-Orczykowska, Katarzyna Rudnicka, Paulina Lemieszek

Supervision: Ilona Sajkiewicz, Katarzyna Krukar, Martyna Pustelniak

Project administration: Justyna Wójtowicz, Ilona Sajkiewicz, Ilona Jasiuk

Receiving funding: Justyna Wójtowicz

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