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EXPERIENCE FROM THE FIELD

Nutrition

Nutritional and growth concerns of vegetarian diets in children

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1 | INTRODUCTION

The exact prevalence of children adopting a vegetarian diet is difficult to determine, owing to varying definitions of vegetarian diet in data collection. However, in general publications describe an increasing prevalence of vegetarian diets worldwide, with rates varying between 2% and 35% of the population ascribing to a vegetarian diet.[1] There are multiple variations of the vegetarian diet (Table 1) based on regional, cultural aspects, and socioeconomic factors. Although vegetarian diets have become popular due to their benefits on environment, they pose nutritional challenges due to the risk of developing nutrient or caloric deficiencies which may impact health or growth in children and adolescents.[2] Table 2 provides a summary of the nutritional deficiency risk associated with each variation, as well as the specific recommendations to ensure adequate nutritional provision.

2 | NUTRITIONAL DEFICIENCY RISKS ASSOCIATED WITH A VEGETARIAN DIET IN CHILDREN

2.1 | Polyunsaturated fatty acids

Vegetarian diets are associated with reduced intake of long-chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).[3] These fatty acids are important for rapid myelination and neurologic development during infancy and childhood. In the vegan diet, algae-derived products can provide a source for EPA/DHA. It is recommended that 1%–2% of the vegan or vegetarian diet calories come from a source with high omega-3 fatty acids (Table 2).[3]

2.2 | Iron

Data is mixed regarding the rate of iron deficiency and anemia in vegetarian children, with rates varying from 4.3% to 73% depending on the study. TARGet Kids! is a primary care, practice-based research network and cohort study in Toronto, Canada. Recent analysis of the TARGet Kids! cohort found no association between a vegetarian diet and serum ferritin levels in children.[2] There is insufficient evidence to suggest a specific monitoring schedule of serum ferritin or hemoglobin levels in vegetarian children. However, guidance should be provided to avoid excessive dietary consumption of inhibitors of iron absorption, such as phytates, oxalic acids, and calcium-containing foods.

2.3 | Calcium and vitamin D

Vegan and vegetarian diets may have lower calcium and vitamin D content due to a lack of natural sources, including dairy and fish. However, analysis of National

TABLE 1 Definitions of subtypes of a vegetarian diet.

Type of vegetarian diet	Foods included/definition
Vegan	Strictly plant-based diet. Exclusion of all animal-derived products.
Lacto-vegetarian	Exclusion of all animal products except dairy.
Ovo-vegetarian	Exclusion of all animal products except eggs.
Lacto-ovo-vegetarian	Exclusion of all animal products except dairy and eggs.
Pescatarian	Exclusion of all animal products except seafood/fish. This diet may include dairy and eggs.
Flexitarian	Occasional inclusion of meat-based foods with regular intake of other animal products like dairy, honey, and eggs.

Health and Nutrition Examination Survey data from 2001 to 2008 showed calcium and vitamin D intake did not differ between vegetarian and nonvegetarian children, with both groups having inadequate intake of calcium and vitamin D.[4] Sources of calcium in a vegetarian diet include green vegetables such as broccoli, Chinese cabbage, collards, and kale. Calcium and vitamin D fortified milk alternatives serve as important sources of calcium and vitamin D in a vegetarian diet.

2.4 | Vitamin B12

Vitamin B12 naturally occurs only in animal-based products, including meat, fish, poultry, dairy, and eggs. Conventional teaching considered the infants at highest risk of B12 deficiency to be those who are breastfed

TABLE 2 Nutritional risks and recommendations for adequate provision in a vegetarian and vegan diet.

Nutrient	Concerns in vegetarian diet	Dietary recommendation
Omega-3 Polyunsaturated Fatty acids	Reduced intake	Dietary supplementation with chia seed, flaxseed, walnut, rapeseed/canola, avocado oils, algae-derived EPA and DHA supplements ***Pescatarians may choose to consume fish/crustacean oils**
Iron	Conflicting data regarding risk of deficiency compared to omnivorous children	**Iron-rich foods:** fortified breakfast cereals, beans, lentils, spinach, tofu, cashews, pistachios **Lacto-ovo-vegetarian sources:** Eggs **Pescatarian sources:** Sardines, Tuna Avoid excess intake of iron absorption inhibitors (phytates, oxalic acid, calcium foods) **Phytates:** chocolate, soy, pinto, kidney, and navy beans, peanuts, chard, spinach, and asparagus **Oxalic acid**: chocolate, soy/miso, tea, coffee, tofu, potatoes/yams, legumes, beets, raspberries, spinach
Calcium	Insufficient intake if dairy avoided	**Calcium-rich foods**: oranges, oatmeal, soy, almonds, beans, broccoli **Milk alternatives:** fortified soy milk, fortified almond milk, fortified pea milk, fortified oat milk, calcium-fortified fruit juices
Vitamin D	Conflicting data regarding risk of deficiency compared to omnivorous children	**Milk alternatives:** fortified soy milk, fortified almond milk, fortified pea milk, fortified oat milk, mushrooms **Lacto-ovo-vegetarian sources:** Egg yolks, cow's milk fortified with vitamin D
Vitamin B12	Risk of deficiency highest in vegan diets Possible deficiency in breastfed infants	Vegetarian/vegan mothers who breastfeed should take specific B12 supplement B12 supplementation recommended in vegetarian/vegan children **Vegan sources of vitamin B12:** nutritional yeast, fortified cereals, tempeh, marmite **Lacto-ovo-vegetarian sources:** cheese, cottage cheese, eggs, milk, yogurt **Pescatarian sources:** Fish, crustaceans, mollusks
Protein	Data suggest lower but adequate protein intake Distribution of amino acid profile less optimal than animal protein	Variety of plant proteins should be consumed, including soy milk, pea protein milk, legumes, nuts/nut butters, tempeh, tofu, kamut, quinoa, wheat berries, oatmilk, plant-based yogurts **Lacto-ovo-vegetarian protein sources:** cheese, cottage cheese, eggs, milk, yogurt **Pescatarian sources:** Fish, crustaceans, mollusks

Abbreviations: DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

by a vegetarian mother. However, data to support the association of vegetarian diet and breastmilk B12 concentration are limited. A 2018 study from the United States illustrated that the prevalence of low B12 levels in breastmilk varied between 15% and 19%, with no statistical difference seen between vegan, vegetarian, and nonvegetarian mothers on average breastmilk B12 content.[5] Vegetarian mothers who are breastfeeding should be instructed to take a B12 supplement. The Recommended Dietary Allowance (RDA) for pregnant and lactating women is 2.6 and 2.8 mcg/day, respectively, while the RDA during infancy is 0.4 mcg/day.[6] Medical providers should have a high index of suspicion for possible B12 deficiency in a breastfed infant with concerning symptoms, which may include developmental delay, involuntary movements, poor feeding, nystagmus, and seizures. The diagnosis of vitamin B12 deficiency may vary by cutoff level and biomarker used. To confirm the diagnosis of vitamin B12 deficiency, it is suggested to check serum methylmalonic acid levels if the serum vitamin B12 level is between 150 and 399 pg/mL (111–294 pmol/L).[6] The rate of B12 deficiency in older children and adolescents varies from 0% to 33% based on the study,[2] but recommendations are universal in that B12 supplementation is needed in vegetarian and vegan children.

2.5 | Protein

A 2019 German study in children aged 1–3 years found omnivorous children had a higher intake of protein compared to vegan and vegetarian children; however, all children had an appropriate median intake of protein.[7] A similar study in older German children aged 6–18 years (VeChi Youth Study) found median protein intake exceeded the goal in all diet groups (vegan, vegetarian, and omnivore), but protein intake was lowest among vegetarians.[8] Plant protein can serve as a complete source of all 20 amino acids. However, the amino acid distribution profile varies and can be less optimal compared to animal protein. With these considerations, variation in plant protein source is important to achieve adequacy and appropriate growth. Examples of vegetarian protein sources include nut butters, plant-based yogurts, and plant-based milk alternatives. If milk alternatives are used, families should be advised to choose one with improved protein content, such as soy milk, pea protein milk, or nut milks supplemented with pea protein.[9]

2.6 | Growth

A systematic review found overall similar results in anthropometric measurements in various cohort studies.[2] The TARGet Kids! Cohort study also examined the relationship between vegetarian diet and growth. This study did not find any association between vegetarian diet and body mass index (BMI) *z*-scores or height-for-age *z*-score. However, children following a vegetarian diet had higher odds of being undernourished, defined as a BMI *z*-score < –2. The German VeChi Diet (aged 1–3 years) and VeChi Youth (aged 6–18 years) study evaluated the anthropometrics of children following a vegan, vegetarian, or omnivorous diet. Both studies showed no differences on average anthropometrics between the diet groups, including average weight and height in the VeChi Diet study and weight, height, and BMI in the VeChi Youth study.

2.7 | Eating patterns

Concerns exist regarding the association of disordered eating and vegetarian diets in children, predominantly during adolescent years. A systematic review evaluating 20 studies from 1986 through 2019 reported an association between vegetarian or vegan diets and eating disorders.[10] Anorexia nervosa was the most common eating disorder associated with vegetarianism. Studies reported a higher percentage of eating disorders in adolescent females compared to males following a vegetarian diet. There was no consistent trend reported regarding the timing of vegetarian diet acceptance and diagnosis of an eating disorder. Physicians and medical providers should be aware of this association, especially if other concerns for body image or weight changes occur.

2.8 | Plant-based meat alternatives (PBMAs)

PBMAs are vegetarian or vegan products designed to resemble the taste and appearance of traditional meats. The most common ingredients used are soy, wheat gluten, and mushrooms. Other ingredients include legume proteins from pea, lentil, lupine or chickpea, and oilseed proteins from rapeseed and canola. Concerns with PBMAs are related to sustainability and their ultra-processed nature as these contain numerous food additives, including added flavors, colors, and emulsifiers. Limited data exists to address these concerns, however a small trial with 20 participants found positive changes in the gut microbiome of consumers who occasionally replaced meat with PBMAs.[11]

PBMAs are typically regulated in a similar manner as other nonanimal foods, including oversight by governmental food safety agencies. However, as with other foods, nutritional adequacy and content may vary from food to food. In an omnivorous model diet with traditional or novel plant-based substitutes, the diets based on novel plant-based substitutes were below daily requirements for calcium, potassium, magnesium,

zinc, and vitamin B12 and exceeded the reference diet for saturated fat, sodium, and sugar. This highlights the risk of increasing undesirable nutrients when less healthy plant-based substitutes are selected.[12]

3 | SUMMARY

Care should be taken to avoid nutrient deficiencies in the pediatric population following a vegetarian diet. Current data suggest that while specific concerns exist for macronutrient intake, a vegetarian diet can be a safe and complete diet for children when detailed and longitudinal attention is given to diversification of nutrient intake. We recommend that any child or family who adheres to a strict vegetarian diet work with a nutrition specialist or registered dietitian familiar with the nutritional concerns of a vegetarian diet. This includes calcium and iron intake as well as sufficient and diverse protein intake. B12 and vitamin D supplementation should be considered in vegetarian children, consistent with previously published recommendations referenced in this review. While data suggest that average anthropometrics are similar between vegetarian/vegan and omnivorous children, there is some concern regarding the risk of being underweight while following a vegetarian diet. Future studies may be helpful in elucidating growth concerns as vegetarian options change and dietary patterns change within specific populations. These changes include fortified PBMAs, which have increased in popularity and may serve as an additional source of protein and micronutrient intake. However, data on their nutritional role in children need further examination. Medical providers should be aware of the association between vegetarian or vegan diets and eating disorders, especially if other concerns for body image are present or weight changes occur.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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