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REVIEW ARTICLE

Clinical implications of vegetarian and vegan diets in child development: a narrative review

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Abstract

Objectives: To analyze the risks and benefits of vegetarian and vegan diet in child development, showing possible nutritional deficits and how to manage them. **Methods:** This is a current narrative review, related to vegetarian and vegan diets in children and their repercussions on development, searched in MEDLINE®, PubMed® and SciELO databases, using the keywords “vegetarian diet”, “vegan diet”, “child development”. **Results:** Despite vegetarian and vegan diets presents risks due to deficit of nutrients involved in vital biological functions, a diet based on vegetables provides clinical benefits, such as a lower incidence of cardiovascular disease, cancer and diabetes. Vegan women who desire to become pregnant should have a well-planned and balanced diet. Breastfeeding is the ideal way and the first option to feed vegetarian/vegan babies; however, if exists an impossibility, there are soy-based formulas on the market. The first meals, at six months, should be rich in protein, iron, zinc and the vitamin B12 is the most worrying nutrient due to its participation in child’s neurological development and must be supplemented if necessary. **Conclusion:** Pediatricians should guide families, alert them about the risks and enlighten that a high-class and well-planned diet does not change child development, although requires periodic monitoring for evaluation and possible supplementation.

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INTRODUCTION

Vegetarianism and veganism have been an intense focus of debate about possible risks and benefits that can cause child development, especially in the early stages of life: pregnancy, lactation and childhood¹.

Vegetarianism is a dietary pattern based on the exclusion of meat intake, subdivided into some types, according to the level of restriction of animal products². This range of vegetarian diets ends up making it difficult to compare and contrast the possible health benefits of this type of diet³. A vegan diet is based exclusively on plant foods, that is, it abstains from all animal derivatives, such as meat, fish, eggs, dairy products and honey⁴.

Every child, at first, starts out as a vegetarian, since the first six months of life include the period of exclusive breastfeeding or, if breastfeeding does not occur, the use of adequate formulas according to the needs of each infant. The introduction of food, then, takes place in the second semester, as a way of providing the appropriate energy and nutritional demand until the child can be included in the family diet⁵.

The *European Society for Pediatric, Gastroenterology, Hepatology and Nutrition* (ESPGHAN), the *American Dietetic Association* (ADA), the *Academy of Nutrition and Dietetics* (AND) and the *American Academy of Pediatrics* (AAP) state that although there is a dearth of information on the introduction of vegetarian food, when well elaborated, the nutritional needs of the infant can be met, without prejudice to the child's cognitive development and weight gain. However, with regard to a vegan diet in the first years of life, ESPGHAN warns that nutritional adjustments are essential, in addition to strict medical supervision and guidance⁶.

Given the relevant role of pediatricians in guiding parents and/or caregivers regarding breastfeeding and food introduction, the objective of this review is to analyze the clinical risks and benefits of a vegetarian and vegan diet in child development, pointing out the possible nutritional deficits and how to solve them.

METHODOLOGY

This is a narrative review, carried out from May to June 2020, through the survey of evidence in updated books and in the MedLine®, PubMed® and Scielo databases. For this, the descriptors "vegetarian diet", "vegan diet" and "child development" were used in Portuguese, English and Spanish.

Articles published in Portuguese, English and Spanish, with availability of abstracts for identification and access to them in full, were used as inclusion criteria, fulfilling the proposals for the purpose of this study. The search resulted in 38 articles, among which those that did not meet the aforementioned inclusion criteria were excluded, totaling 20 articles and a book of pediatric updates regarding the topic and the proposed objective.

RESULTS AND DISCUSSION

Risks and benefits

After all, is vegetarian food in childhood safe? The initial answer should be exactly the same if we asked about an omnivorous or lacto-ovo vegetarian food pattern: it depends¹. ESPGHAN warns of greater risks of developing nutritional deficiencies in vegetarianism/veganism, while the ADA and AND state that this eating habit is nutritionally adequate for all stages of life, including childhood, pregnancy and lactation, as long as they are well planned, monitored and with the correct distribution of quality food, as in any omnivorous and balanced diet^{1,5,6}.

Whatever the reason you decide to follow a vegetarian diet, you should know its advantages and disadvantages, especially in childhood. The biggest controversy stems from the possible risks caused by the nutrient deficit, which can compromise child development. Proteins, fatty acids, omega 3, iron, calcium, zinc, iodine, vitamins D and B12, riboflavin and selenium are the nutrients involved in vital biological functions during growth and which may be insufficient in this diet, and especially in vegan ones³.

On the other hand, it is known that a diet based on plant foods, whole grain cereals, fruits, nuts, legumes, among others, provides important clinical benefits, such as a lower risk for hypertension, coronary heart disease, obesity, and some types of cancer. and also adult-onset diabetes. It is believed that these benefits come from the high content of fiber, phytochemicals and antioxidants present in this diet, in addition to having a reduced content of cholesterol and saturated fats⁵.

Compared to non-vegetarians, vegetarian children tend to consume more fruits, vegetables and legumes. Therefore, the intake of fiber, vitamins A, C and E, folate, magnesium and potassium is generally higher; while the consumption of total calories, saturated fats, vitamins D and B12 and zinc may be lower. In addition, vegetarian and vegan children and adolescents tend to consume less sugars and processed foods. In general, their dietary pattern is closer to official recommendations than typical Western diets⁷. In Table 1, it is possible to observe a comparison between the absorption of nutrients in a vegetarian and omnivorous diet.

Considerations about the vegetarian and vegan pregnant woman

For pregnant women, naturally, there is an increased demand for essential nutrients for the proper development of the fetus. A low Body Mass Index (BMI) or deprivation of these micronutrients during pregnancy can have direct consequences in childbirth and, consequently, irreversible damage to the child's development, in physical, cognitive and metabolic aspects, until they reach adulthood⁸.

Table 1. Comparison in nutrient absorption of vegetarian diets in relation to omnivores.

lower intake	higher intake
Iodine	Magnesium
B12 vitamin	Vitamin C
Zinc	folate
Calcium	Fatty acids and Omega3
Saturated Fat and Cholesterol	Potassium
Iron	Vitamin E
Vitamin D	carotenoids
Energy	flavonoids

Source: Canto AM (2018)³.

With the evolution of pregnancy, the need for proteins increases by about 37%, mainly in the third trimester. Studies show that proteins from vegetables are satisfactory when they reach the necessary supply. In addition, there is evidence that a vegan diet reduces the risk of preeclampsia and gestational diabetes⁸.

Considering that, in general, women do not change their diet during pregnancy, it is imperative that vegetarians/vegans have a well-planned and balanced diet during and before pregnancy, performing serum levels of vitamin B12 and iron regularly⁸. Furthermore, it should be noted that all pregnant women need appropriate nutritional supplementation, such as iron, folic acid and vitamin D and B12, especially for vegans⁸.

Exclusive breastfeeding and use of formulas

The World Health Organization (WHO) and ESPGHAN recommend exclusive breastfeeding up to the first six months of life, maintaining it up to two years^{2,5,6}. Exclusive breastfeeding is understood as offering only breast milk without any other liquid or solid, with the exception of vitamins, mineral supplements or drugs, when necessary². This guidance is based on the advantages of exclusive breastfeeding, such as nutritional safety for the infant and the reduction of allergic and infectious episodes^{2,5,6,9}. In addition, the breastfeeding process is free from contamination, in contrast to the use of infant formulas, which during their preparation may present some risk. Breast milk also contains substances not found in other types of milk or formulas, such as immunoglobulins and the bifid factor, which stimulate the formation of intestinal bacterial flora⁹.

As in omnivorous families, breastfeeding is the ideal first food option for vegetarian and vegan babies, and should be encouraged in every consultation^{2,3,7,9,10}. Breastfeeding rates in families that opt for these eating styles tend to be higher than in omnivorous families⁵. Vegetarian/vegan mothers should be instructed and reassured about their milk, as it is nutritionally adequate and its composition is similar to that of non-vegetarian and

non-vegan mothers, with the exception of vitamin B12 levels in vegan breastfeeding mothers^{2,3,9}.

Vitamin B12 is present only in foods of animal origin and, therefore, it may be below normal levels in the diet of plant origin⁹. Substantial studies show that babies breastfed by vegan mothers can present irreversible neurological damage, and these potential damages should be alerted^{2,11,12}. Thus, if the lactating woman is not ingesting reliable sources of B12, she should be supplemented to ensure a good concentration in breast milk⁴. In case of doubt, both mother and infant should be supplemented². Supplementation for infants up to six months of age should be 0.4mcg/day^{2,3,6}.

Despite the benefits and strong recommendations on breastfeeding, there are situations that limit exclusive breastfeeding, such as mothers with HIV or HTLV, herpetic breast lesion, vaccination for less than 14 days against yellow fever, chemotherapy or radiotherapy, including vegan and vegetarian mothers. Therefore, there is a need for alternatives aligned with the nutritional choice of these families⁹.

In the same way that cow's milk should not be introduced before two years of age, due to numerous harm to the child, the plant extract, equivalent to animal milk in veganism, can only be used as an alternative after this period. Thus, alternatives for the nutrition of children weaned in this age group are restricted, leaving infant formulas with isolated soy protein, which must comply with international recommendations^{2,3,6,9-11}. They have been used for over 60 years and have been shown to be safe and effective in replacing breast milk. Although they have less nutritional value than milk formulas, they are capable of promoting normal growth and development in full-term infants from birth, similarly to breast milk^{2,9}.

However, despite being nutritionally adequate, soy-based infant formulas have a high concentration of aluminum, phytates and phytoestrogens, and there are still discussions in the literature regarding their safety, especially with the long-term effects after such an early exposure^{2,11}.

Lacto and lacto-vegetarian families can use cow's milk-based infant formula. There are some formulas prepared from organic cow or goat milk that meet the European Union guidelines for infant formula and are the choice of many vegetarian families.

For infants from vegan families, despite the above considerations, the best option is infant formula based on isolated soy protein, which can replace animal milk after six months of age^{7,10}. Other beverages based on plant extracts, such as almonds, oats and rice, whether industrialized or homemade, have a much lower amount of protein and do not serve as a substitute for cow's milk for infants, even those supplemented with calcium, in addition to not being used in preterm children, as they do not reach the

nutrient concentrations recommended for them^{2,7,11}. It is worth mentioning that the use of these vegetable drinks, often mixed with fruit and vegetable juices, produce cases of severe malnutrition, neurological disorders and even death^{7,10}.

The ADA establishes that vegetarian children with an adequate supply of breast milk or infant formula have normal growth^{3,5}. However, there is a strict need for follow-up and monitoring of these children, especially infants, by health professionals, in order to ensure satisfactory levels of nutrients, either through diet or supplementation^{3,11,12}.

Food introduction in vegetarian and vegan children

From the sixth month of life onwards, complementary feeding should be introduced, as the infant's needs in relation to proteins, zinc, iron, some vitamins and total energy are more difficult to be met by exclusive breastfeeding^{3,5}. The introduction of vegan or vegetarian food follows the same guidelines as an omnivorous diet¹³.

The beginning of food for vegetarian and vegan children requires a wealth of micronutrients and represents a reduced supply of saturated fats, especially when well planned and varied, considering their active participation in the growth of this age group^{2,5,7}. The first meals, at six months, should be rich in energy, protein, iron, zinc and may include hummus, tofu, well-cooked vegetables and avocado puree¹⁴. The British Nutrition Foundation attests that, despite having a lower caloric intake, children on a vegan diet grow adequately^{3,14}.

An important aspect to be monitored is BMI, which, despite remaining within normal parameters, may present values lower than those in omnivorous children^{3,5}. On the other hand, there are also reports of caloric intake below the recommended, in cases of little diversification and poor execution of the diet. This fact reiterates the imminent need for planning and monitoring the diet of vegan/vegetarian children, in order to avoid nutritional deficiencies and growth retardation³.

Due to these counterpoints, anthropometric data must be periodically controlled, for early intervention in case of deviations from normality³. In addition, extra attention should be directed to some nutrients, namely, proteins; the elements iron, calcium, zinc and iodine; components of omega 3 and vitamins D and B12, the latter being the only one that has a consensual indication of supplementation^{3,5}. In comparative studies of vegetarian and omnivorous children, the intake of other essential micronutrients, such as folate, magnesium, carbohydrates, fiber, vitamins A and C, is in accordance with reference values¹⁵.

Table 2 briefly lists plant food sources of the main nutrients that have been the focus of attention in vegetarian and vegan diets.

Such diets have a sufficient amount of proteins that even exceed the daily protein quota, as they are easily found in foods of plant origin. For satisfactory physical and metabolic development, the diet must be diversified, containing soy products, legumes, tahini, oilseeds, nuts and whole grains, which concentrate energy and adequate amounts of amino acids, in addition to the excellent combination of rice and beans^{5,9,16}. Vegetables are the main meat substitutes and can be introduced in the form of baby food, soups, purees or salads for older children^{1,7}.

However, the protein needs of vegan children may be slightly higher than non-vegan children, due to differences in the composition of plant-based amino acids. The ADA recommends a contribution of 30 to 35% more for 1 to 2 years old, 20 to 30% for 2 to 6 years old, and 15 to 20% for people over 6 years old¹⁴. Furthermore, food should be offered more frequently to the child, in order to reach the ideal energy intake¹⁶.

Iron bioavailability is slightly lower in plant-based foods compared to animal foods. In vegetarians/vegans, it is necessary to pay attention to the possibility of iron deficiency anemia, although there are no reports of a higher incidence in this group, in addition to damage to neuropsychomotor and immune development. The biggest concern, however, is in its absorption deficit, since, in vegetable inputs, its availability is presented in reduced bioavailability, in the non-heme form, being necessary the combination of foods rich in vitamin C so that the absorption of iron is optimized. For this, it is also recommended to consume germinated seeds, oilseeds and cooked vegetables, avoiding association with coffee and tea during meals^{1,3,5,16,17}.

The Brazilian Society of Pediatrics (2018)¹⁸ advises iron supplementation from three months to two years of age for all children, vegetarian or not, as shown in Table 3.

The serum balance of calcium and zinc between vegetarians and non-vegetarians does not show significant differences^{3,5}. A tablespoon of sesame seeds or a plate of broccoli or other cruciferous vegetables contains the same amount of calcium as a glass of animal milk, and also with increased absorption^{1,5}. However, in addition to the concern with the amount of calcium and zinc bioavailable, it is essential to pay attention to phytates and oxalates present in plant foods and to the increased consumption of fibers inherent to vegetarianism/veganism, which hinder the absorption of these minerals by the body and, thus, lead to harm to growth, the immune system and bone health^{3,16,17}.

Vitamin B12 is the most critical nutrient to be monitored in a vegan diet, as it plays an important role in cell production and in the maintenance of the nervous system, and its deficiency can lead to megaloblastic anemia, an increased risk of cardiovascular diseases and, most worrisome, to neuronal damage such as muscle hyporeactivity, muscle hypotonia, irritability, vomiting, apathy, regression

Table 2. Vegetarian sources of the main nutrients for an adequate diet.

Nutrient	Main sources	Recommendations
Proteins	<ul style="list-style-type: none"> Legumes (chickpeas, lentils, beans, soybeans and derivatives, tofu, peanuts) Seitan* Seeds and nuts Eggs and dairy products 	Each daily meal should consist of at least a portion of one of these foods, especially vegetables. *Not recommended for those allergic/intolerant to gluten, as it contains a high amount of this substance.
Iron	<ul style="list-style-type: none"> Vegetables and legumes Seeds and nuts whole grains desiccated fruits some vegetables 	To optimize non-heme iron absorption: <ul style="list-style-type: none"> Combine foods rich in iron with those rich in vitamin C in the same meal for better absorption of non-heme iron by the body. Avoid drinking coffee and tea during meals.
Calcium	<ul style="list-style-type: none"> Vegetables and vegetables in the cabbage family, including cabbage, turnips, broccoli, watercress, arugula, taro and other leafy greens dairy products Calcium-fortified soy milk and yogurt Tofu Curd with Calcium Salts Almonds, sesame and chia, oranges, dried figs, wholegrain bread 	For adolescents, advise on the greater need to eat foods rich in calcium, due to a higher rate of bone mineralization in this age group.
Zinc	<ul style="list-style-type: none"> Seeds (pumpkin, sesame, sunflower) Nuts (walnuts, almonds, hazelnuts, chestnuts) Vegetables Cereals (oats, quinoa) Tofu 	Fermenting bread, prolonged soaking of vegetables before baking, and roasting or soaking nuts decrease the content of phytates that are harmful to their absorption and increase the bioavailability of zinc and iron.
Iodine	<ul style="list-style-type: none"> iodized salt Non-organic dairy products** Algae*** 	**Conventional dairy products contain iodine because the cow's feed is enriched with this trace element. ***Kombu, arame, hiziki and spirulina algae have an excessive iodine content and are not recommended in childhood, pregnancy or lactation.
Omega 3	<ul style="list-style-type: none"> Nuts, flaxseed and chia Soy and derivatives Canola oil green leafy vegetables Some varieties of eggs 	Supplement with vegetable DHA (algae oil) during pregnancy, lactation and in the first year of life. 1 dessert spoon of linseed oil or 15g of walnuts per day.
Vitamina D	<ul style="list-style-type: none"> Dairy and fortified foods Some varieties of mushrooms 	Greater attention in winter and those less exposed to the sun.
B12 vitamin	<ul style="list-style-type: none"> fortified foods Dairy products and eggs 	Requires supplementation.

Sources: Chordà et al. (2016)¹; Biarge MM (2018)⁷; Fonseca CRB, Fernandes TF (2018)¹⁶.

of gross motor development and thin, psychomotor impairment, growth retardation and muscle atrophy^{1,5,11}. Some plant sources, such as cyanobacteria and soy derivatives, have a greater amount of the inactive form of the vitamin, making their consumption insufficient in relation to the consumption of animal sources. Therefore, its supplementation is recommended for all supporters of vegetarian/vegan diets at all ages^{1,5}.

B12 deficiency should be monitored not only by a reduction in serum dosage, but also by macrocytosis, an increase in homocysteine and methylmalonic acid in the blood or a reduction in holotranscobalamin, which corresponds to the bioavailable active fraction, functioning as an early marker of the deficit. vitamin¹. Greater attention should be given to those who already had reduced B12 stores prior to dietary changes⁵.

Supplementation can be made with foods fortified with B12 or medication, preferably orally and for an indefinite period, with 10mcg/day being sufficient to prevent deficiency^{19,20}. The most commonly found supplements in Brazil are 500-1000mcg; however, no adverse effects have been reported from vitamin B12 overdose, as it is water-soluble²¹. Through fortified food, it is possible to prevent the deficit as long as consumption reaches 2.4mcg/day²⁰.

Currently, vitamin D deficiency is commonly found in the population, whether vegan or omnivorous, due to less direct exposure to the sun, exposing children to the risk of rickets. It can be exogenously replaced by the plant form ergocalciferol (vitamin D2), for vegetarians/vegans^{1,5,16}.

Table 3. Recommendations for iron supplementation in infants.

Situation	Recommendation
Full-term newborn, with adequate weight for gestational age, exclusively breastfed or not	1 mg/kg/day of elemental iron from from the 3rd month to the 24th month of life.
Full-term newborns weighing suitable for gestational age using less than 500 mL of infant formula per day	1 mg/kg/day of elemental iron from from the 3 rd month to the 24 th month of life.
Full-term newborns weighing less than 2500g	2 mg/kg of body weight/day, starting at 30 days for one year. After this period, 1mg/kg/day plus one year
Preterm newborns weighing between 2500 and 1500g	3 mg/kg of body weight/day, starting at 30 days for one year. After this period, 1mg/kg/day plus one year
Preterm newborns weighing between 1500 and 1000g	3 mg/kg of body weight/day, starting at 30 days for one year. After this period, 1mg/kg/day plus one year
Preterm newborns weighing less than 1000g	4 mg/kg of body weight/day, starting at 30 days for one year. After this period, 1mg/kg/day plus one year

Source: Brazilian Society of Pediatrics (2018)¹⁷.

CONCLUSION

It is concluded, therefore, that when choosing to insert a child, even in the first years of life, on a vegetarian or vegan diet, the pediatrician's job is to respect and advise the family, warning about its risks. In general, this diet does not alter child development, as long as it is very well planned and diversified. For this, periodic consultation with the pediatrician and nutritionist is eminently necessary. Furthermore, as it is part of the child's neurological formation, vitamin B12 must be monitored and supplemented orally, in order to avoid irreversible damage, in addition to the control and, if necessary, supplementation of iron, zinc and calcium. Finally, it is important to highlight that, in any dietary pattern, the diet must be based on quality products, prioritizing fruits and vegetables; without excess sugars, salt and synthetic additives and with the least processing possible, since ultra-processed foods of plant origin are still as inadvisable as ultra-processed foods of animal origin.

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