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ORIGINAL ARTICLE

Nutrition and growth of vegetarian and vegan children

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Abstract

The present term paper consists of a systematic review on the nutrition and anthro-pometry of vegetarian children. For the preparation, articles were selected from three databases and inclusion and exclusion criteria were used to define which publica-tions would be part of our references. The vegetarianism is growing, and health pro-fessionals are not prepared to meet the needs and demands of this pediatric popu-lation, given the scarcity of research on the subject. In the evaluation of nutritional aspects, it was seen that the balanced vegetarian diet is capable of providing ade-quate growth and development, however, some elements deserve special attention, such as vitamin B12, the fatty acids of the omega 3 family and the dosage of ferritin; other nutrients such as calcium and vitamin D deserve attention, but intakes and replacement indications differ little from the general population. Regarding anthro-pometry, vegetarians show adequate growth, despite the tendency to lower weight and height, all within the reference values. Was also evaluated the particularities of vegetarian infants, in relation to breastfeed-ing, use of formulas and food introduction. It is the role of the health professional being able to guide and support families that choose to make this food choice, and that is why it is so important that researches grow and invest in classes on this topic in universities and medical residency programs.

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INTRODUCTION

In the last 10 years veganism has grown in western societies, it is estimated that the number of vegans has grown by 350% in the last decade[1]. However, scientific studies and medical knowledge regarding the nutrition of the pediatric population with this eating habit are still scarce, and it is necessary to study the peculiarities of this diet so that we can provide better care to our patients.

In the US, interest in vegetarianism has increased for a variety of reasons, including the increased number of vegetarian nutrition courses, the expansion of animal rights, the availability of vegetarian recipes on websites, and the growing public attitude of ordering meatless dishes in restaurants. , which discloses such eating habits[2].

In Germany, however, it is believed that the growth of the vegetarian food market and the dissemination of information on vegetarianism have contributed to this change[3].

The prevalence of vegetarians and vegans is very different in each region; in Europe as a whole, 8 to 10% of the adult population is vegetarian[4]; in France 2% of the general population is vegetarian[1]; in Germany there has been an increase from 7 to 10% of vegetarians in the last 10 years[5], with 0.3 to 1.6% of the population being vegan[3], and among German adolescents 2% of boys and 6% of girls classifying themselves as vegetarians[5]; in the USA, in 2005, 3% of the population aged 8 to 18 years was vegetarian, 1% being vegan[2]; while there are countries where these values are much higher, such as India and Australia, where 30% and 11.2% of the population are vegetarian, respectively[1].

The reasons reported by vegetarians and vegans for choosing this diet are diverse, including ethical[4], moral, religious[5], health[6], animal welfare[7], concern for the environment, economic reasons, world hunger[2], among others.

Vegetarians can be classified as follows: lacto-ovo vegetarians (eat eggs and dairy products, but do not consume any meat or fish), lacto-vegetarians (eat dairy products, but do not consume any meat or eggs), ovo-vegetarians (eat eggs, but do not eat any meat or dairy products), pescovegetarians (eat fish, eggs and dairy products, but do not consume other types of meat), flexitarians (occasionally eat small amounts of animal products), vegans (do not consume no animal products) and raw vegans (do not consume any type of food of animal origin or cooked foods)[5].

The dietary pattern of vegetarians has its particularities; according to a Ghanaian study, vegetarian children eat similar food groups to omnivorous children, but vegetarians consume more leafy greens and fruits[8]. A similar result was seen in Spain, where vegetarian children tend to eat more fruits and vegetables, as well as having a lower intake of sweets[4].

Another relevant fact is that studies show that vegetarians are at a higher socioeconomic level[5], which can influence their diet.

METHODS

The preparation of this systematic review was based on the recommendations of Galvão and Ricarte (2019)[9], and the selection of articles was guided by the PRISMA, 2015 diagram, as guided by the authors[9].

Three databases were selected to search for scientific articles: Embase, MEDLINE and SciELO. The search keywords were " *vegan children", "vegetarian children", "vegan", "vegetarian",* "vegetarian child", "vegan child" and "vegetarian diet in children". 252 articles were found in Embase, 134 articles in MEDLINE and 62 in SciELO.

In Embase, age (" *infants* ", "1-12 years" and "adolescents"), human studies and type of work (controlled study, larger clinical study, clinical article, human trial, *guideline* , *cross-sectional study,* clinical trial, cohort analysis, systematic review, randomized control *trial*, prospective study, meta-analysis, retrospective study, case control, controlled clinical *trial* , clinical study, clinical *trial* , evidence-based medicine, interventional study, clinical protocol, control group, evidence-based practice), leaving a total of 177 articles. The abstracts of these 177 articles were read and the works with the greatest impact were selected, leaving 47 publications.

In MEDLINE and SciELO, the works with the greatest impact and best described were selected, with a total of 9 and 4 articles chosen, respectively.

In a total of 60 works selected from the three bases, the following inclusion criteria were applied: having data referring to the pediatric population and being original works or recommendations from societies; and the following exclusion criteria: articles written before 1986 and language other than Portuguese, English or Spanish.

After applying the criteria, 13 studies remained, which were used in the preparation of this systematic review.

RESULTS

Anthropometry

The reviewed studies show that children who adopt a vegetarian diet can have adequate growth and development, as long as the diet is balanced and well-balanced and the nutritional needs are met, according to a study carried out in Ghana, which analyzed 26 lacto-ovo vegetarian children from birth and 26 omnivores, evaluating clinical history, anthropometry, laboratory tests and food intake[8]. However, there is work that considers that this can only be achieved if some foods of animal origin are included in meals[5].

In general, vegetarians and vegans have normal growth, however, they tend to be lighter (especially those under 5 years old)[3], lower[7] and have a lower BMI[4].

When comparing anthropometric data (weight, height and BMI) of vegetarian children, it was seen that those who adopt this diet from birth and those who become vegetarian after a certain age are similar to each other[2].

Furthermore, in the study carried out in Taiwan, in which anthropometry, laboratory tests and food records of 21 vegetarian children and one of their parents, and 28 omnivorous children and one of their parents were analyzed, it was seen that there was no correlation between the anthropometric indices. in the family[10].

Stature

All studies used in this systematic review show no significant difference between vegetarians and omnivores, as well as heights within the normal range for the majority of the vegetarian population[7,10,11]. However, there is a tendency for vegetarians to be smaller, especially boys, who are still on average at p50 or p55 of height curves[7,6]. A study is cited in which only the population aged 10 to 17 years had shorter stature than omnivores, however, this was not repeated in other studies[5].

The German study evaluated 430 children aged 1 to 3 years, of whom 139 were vegans (excluding *raw food eaters*), 127 vegetarians and 164 omnivores, and compared food recall, clinical anamnesis and anthropometry among them. In the evaluation of German vegetarian and vegan children, it was seen that some patients were classified as "*stunted*"/" *stunting*" (previous malnourished, according to the Waterlow classification used by the WHO[12]) or "very short stature"; of the 8 who entered this group, 2 had a very low energy intake and were exclusively breastfed for more than 6 months, one of whom was born SGA (small for gestational age) and the other had parents with below-average stature. German; 3 children only had parents who were below the German average height; 1 child was just born SGA; and 1 was exclusively breastfed for more than 6 months, in addition to having parents with a height below the national average[3]. This suggests the importance of proper nutrition for healthy growth.

Weight

According to the American Dietetic Association, some studies show that vegan children tend to be thinner[2], within the normal range for age, however, most studies that evaluated weight had results without statistically significant difference, even with this trend[6].

In a Taiwanese study, the weights of vegetarian children were similar to those of omnivores, with an average weight of 21kg and 21.4kg, respectively[10]. In the United Kingdom, patient weights were, on average, around p35 on the growth curve[7], tending to remain below p50[6].

When evaluating weight in relation to height, there was also no significant difference between vegetarians and omnivores[3].

Despite similar weights, the incidence of thinness or "*wasted*"/"*wasting*" (acute malnourished, according to the Waterlow classification used by the WHO[12]) was higher in the vegan population than in omnivores[3]. Some reviews on which the German Society for Pediatrics and Adolescent Medicine (DGKJ) relied to write their position on vegetarian eating also saw some difference in weights, with a difference of 4kg between vegetarians and omnivores aged 11 to 14 and weights minors within the population aged 10 to 17 years in the study by Fleimish[3].

In line with previous data, diets based on animal products are more related to a trend towards higher rates of overweight, with an incidence of 3% among omnivores, 2.4% among lacto-ovo vegetarians and 2.2% among vegans.[3] Obesity follows the same line, with a higher incidence in the omnivorous population[10]. However, despite this trend, there was no significant difference between the weights of the groups[3,11].

When evaluating the families of these children, it was seen that omnivorous parents had a higher proportion of obesity than vegetarian parents, as well as their children[10], which may reflect the trend described above.

BMI

As well as weight and height, in general, there was no significant difference between the BMI of vegetarian and omnivorous children[10,13]. However, some studies on which the American Dietetic Association and the German Society of Pediatrics and Adolescent Medicine (DGKJ) are based to write their positions have seen that vegetarians tend to have a lower BMI[2], especially in adolescence, with such a difference being seen within the population aged 10 to 17 years[5].

Weight to height ratio

The weight-to-height ratio can be calculated using the following formula: observed weight/expected weight (p50) for observed height[12].

There was no significant difference in the relationship between vegetarians and omnivores[10].

Head and thoracic perimeters

Two British works were selected; the first of them was a prospective study that evaluated the food recall, clinical history and anthropometry of 20 vegan children[7]. The second of them, made by the same author, also analyzed the recall, anamnesis and measurements of children born vegan and children of vegans[6].

Both the head circumference and the chest circumference of British vegetarian children were mostly within normal limits[6]; in the other evaluation, the head circumference measurements of vegetarians were, on average, at p90 of the growth curves[7].

Body composition

Evaluating the percentage of body fat, the results were not very different from those found for anthropometry, however, significant differences were seen. Vegetarian children have a lower percentage of body fat when compared to age-matched omnivores[5], being 19.24% and 21.77%, respectively[13]. The fat/lean mass ratio followed the same pattern, being lower in vegetarians, with 0.24 vs. 0.29 in omnivores[13].

bone composition

The bone status of vegetarians is a subject of great interest, given the lower calcium intake that may be present in vegetarian and vegan diets, as will be described later.

In Poland, a cross-sectional study evaluated 53 lacto-ovo vegetarians (who had this diet since birth) and 53 omnivores, matched for age and sex, healthy, with adequate physical activity and a mean age of 7 years (ranging from 5 to 11 years)., in order to determine whether there are differences in bone composition between the two populations, comparing the clinical evaluation, laboratory tests (adipokines, PTH, vitamin D and bone metabolism markers) and bone mineral density (BMD) of the groups[13].

Laboratory evaluation showed similar levels of adiponectin, osteocalcin and PICP (carboxyterminal procollagen type I propeptide), the latter two markers of osteoblastic activity. Serum levels of ICTP (*crosslinked carboxyterminal telopeptide* of type I collagen), a marker of bone resorption, were higher in vegetarians (1.94 vs. 1.76ng/dl in omnivores). And the leptin dosage was lower in vegetarians (1.39 vs. 2.94ng/dl in omnivores), reflecting the lower percentage of body fat[13].

Although osteocalcin levels are similar in the 2 groups, the dosage of carboxylated osteocalcin (c-OC), which is essential for bone formation, tends to be higher in vegetarians, probably due to the higher intake of vitamin K, which is responsible for the carboxylation. A positive correlation was seen between this marker and nutritional parameters adjusted for total energy intake (vegetable protein, phosphorus, magnesium and fiber) in vegetarian children[13].

The bone mineral density of the participants was evaluated by total and spinal dual energy X-ray absorptiometry (DXA), with values for vegetarians and omnivores of, respectively, 0.496 vs. 0.877 (total) and 0.194 vs. 0.583 (column)[13].

Parathyroid hormone (PTH) levels were higher in vegetarians (40.8 vs. 32.1pg/ml); and similar vitamin D dosage in the 2 groups, with only approximately 40% of the children in both groups having adequate levels, which may have repercussions, since the osteocalcin gene and regulation are dependent on this nutrient[13].

In the end, it was seen that the BMD z-score is lower in vegetarians, however, there is no such difference when evaluating the absolute values; moreover, BMD z-score was not correlated with bone metabolism markers, adipokines and nutritional variables, but strongly correlated with anthropometry[13].

Still in relation to bone health, the lacto-ovo vegetarian population has the same risk of fracture as omnivores, however, the vegan population has an additional risk of 30%[2]; some studies show that this higher risk refers to those with low calcium intake[4].

nutritional aspects

Two aspects are relevant in relation to general diet, they are: the energy intake received by vegetarians and the feeding of infants, including breastfeeding, use of formulas and food introduction.

Caloric intake is an important determinant of growth rate, and among vegetarians, the main energy sources are cereals, legumes and nuts[6]. In the studies that served as the basis for this work, most of the vegetarians' caloric intake was similar to that of omnivores[3,7,8,10], in addition to meeting the recommended daily requirement for most or all children[4,13]. In the German study that also evaluated the caloric density (kcal/g) of vegetarian food, it was similar between the two groups, but tended to be denser in omnivores[3]. In the recommendations of the German Society of Pediatrics and Adolescent Medicine (DGKJ) reference is made to the study by Fleimsh, in which a lower caloric intake was seen among vegetarians aged 6 to 17 years, but also mentions that in other articles there was no difference[5]; in the evaluation of British children, vegans showed a lower caloric intake when compared to omnivores, especially those aged 2 to 4 years[6].

As a vegetarian diet is often made up of fruits and vegetables, it tends to be bulkier, rich in satiety-enhancing fiber, and less calorie-dense compared to omnivorous. This should receive attention from parents and health professionals so that children's intake is not bulky and low in calories, thus compromising the necessary nutritional intake[6].

In relation to breastfeeding, some important points were also seen. Vegetarian infants tend to be exclusively breastfed and supplemented for longer, although the proportion of babies who were breastfed at some point did not differ between groups[3]. The average breastfeeding time was 15.5 months for the British[7]. The Ghanaian work, on the other hand, showed a slightly different result, in which omnivores were breastfed for longer than vegetarians (16.6 vs. 13.3 months, respectively), despite the fact that in both groups 100% of the children were breastfed[8].

It is a consensus that in vegan infants who are not breastfed, soy-based infant formulas are the first supplementation option[4], however, there are studies that also recommend the use of rice-based formulas[1]. The consumption of these formulas should be encouraged up to 6 years of age or more[1], and plant-based drinks that do not fit the classification of infant formula cannot be the infant's main drink[14].

The introduction of food in vegetarian infants is little different from omnivores, it is suggested to offer tofu, eggs, hummus, lentils, peanut butter, soy-based yogurts and vegetables rich in vitamins A and C. Regarding the age of introduction of each foods, those that have specific recommendations are: tahini that can be offered from the 6th month of life, honey and seaweed that must be offered after one year of age, and seeds such as chia and flaxseed that must be offered after one year of age. age, preferably crushed due to the risk of choking[6].

carbohydrates

Carbohydrate intake was higher among vegetarians in two of the three studies that aimed to assess this data, but in both, keeping within the reference value[3,13]; in one of the analyses, the proportion of calories from carbohydrates was 58.2% for vegetarians and 52% for omnivores[13]; in the other, it was 56.2% for vegans, 54.1% for lacto-ovo vegetarians and 50.1% for vegans[9]. In the third study, there was no significant difference between the two groups[10].

Sugar

In general, vegetarians tend to consume less sweets[15]. However, when evaluating the sugar intake as a whole (added or intrinsic to foods), it was seen that vegetarians may have a consumption above the recommended values, due to the higher intake of fruits and natural juices[7]. As this additional consumption is accompanied by nutrients and is not related to the worsening of dental health, it was not considered a food error[7].

In the German preschooler evaluation study, omnivores were found to add more sugar to their food (5.3% in omnivores vs. 4.5% in ovo-lacto vegetarians vs. 3.8% in vegans), however, after made the final adjustments to the research, there was no significant difference between the 3 groups and consumption was within the limit of 5 to 10% of added sugar in foods determined by the WHO[3].

fats

All studies showed a lower intake of total fat and saturated fat in vegetarians when compared to omnivores, and this contributes to the lower caloric density of vegetarian diets, which has already been mentioned[6]. When the caloric proportion of the diet derived from fat was evaluated, it was seen that in vegans this value was 31.2%, lacto-ovo vegetarians 33.5% and omnivores 36%[3], showing the contribution of foods of animal origin to the contribution of fat. As expected, when evaluated in isolation, it was seen that cholesterol intake is often lower in vegetarians[2,15] and in the evaluation of vegan children in the United Kingdom, a lower intake of fatty acids was seen than in omnivores[7].

Polyunsaturated fatty acids

Omega 3 and 6 polyunsaturated fatty acids, so called because they contain two or more unsaturations, cannot be synthesized by our body. Vegetarian food is rich in polyunsaturated fatty acids[15], with an intake higher than the omnivorous population[5] and, sometimes, above the recommended[7].

Omega 3 acids (alpha-linolenic, EPA and DHA) are present in large amounts in fish and crustaceans, and to a lesser extent in walnuts, flaxseed and vegetable oils such as canola and soy[2], thus, vegetarians usually have an intake below the normal limit. reference value[5]. Omega 3 is present in breast milk[6], however, children who are not breastfed should receive infant formula supplemented with this nutrient; when the formula in use is not fortified, the use of the aforementioned vegetable oils should be favored in the child's diet[1]. Supplementation from microalgae is controversial[5] and should be evaluated according to the patient's age, intake and demand[15]. The recommended replacement dose is 100mg of microalgae per day for children from one year of age[1].

On the other hand, omega-6 fatty acids (linoleic, g-linolenic and arachidonic acid) are predominantly present in vegetable oils, nuts and seeds, therefore, vegetarian diets generally have a high intake[7] and are richer than omnivores[2].

The high intake of omega 6 associated with the low intake of omega 3 causes the omega 6/omega 3 ratio to be high, which can be harmful, since they compete for the same enzymes and, therefore, the conversion of alpha-acid is impaired. linolenic acid in DHA, which plays important roles in the retina and central nervous system; attention should be paid to the possible damages of this high ratio, since the vegetarian diet has lower intakes and serum levels of DHA[7].

proteins

Currently, the main sources of protein for vegetarians are cereals, legumes and nuts, and, when included, also dairy products and eggs[6].

Although in both groups protein consumption was predominantly within the reference values, vegetarians had a lower protein intake than omnivores[3,10,13] in the references used. The main difference lies in the fact that one of the groups predominantly consumes protein of plant origin and the other of animal origin[13] and, in general, protein from plants is considered inferior in relation to that of animal origin[15].

Vegetable proteins are capable of supplying all essential amino acids, however, adjustments to the amount ingested are necessary in order to meet these needs[2]. Thus, protein intake is in line with the requirements when there are sufficiently varied sources to guarantee the supply of essential amino acids[1].

fibers

Vegetarian food is rich in fiber[15] and the intake by those who adopt this diet is much higher than that of omnivores, and this was shown in all the articles used for this work[7,8,10,14]. In Poland the values for vegetarians and omnivores were 20.4 vs. 14.2g/day[13]. In Germany, it was 21.8 vs. 16.5 vs. 12.2g/1,000kcal for vegans, lacto-ovo vegetarians and omnivores respectively[2].

Trace elements and vitamins

Although one of the studies used in this review mentions that there may be nutritional deficiency in vegetarians[11] , the other sources showed that vegetarians ingest nutrients in amounts that meet the recommended values[15] and that the vegan diet even offers it in larger amounts than the omnivorous diet., except for calcium and vitamin B12[7]. An English study also showed that the density of nutrients ingested (amount of nutrient per 1,000 kcal consumed) is higher in vegans than in

omnivores[6]. What must be taken into account is the fact that the more restricted a diet, the greater the risk of nutritional deficiency and the greater attention the patient should receive[5].

In addition, the vegetarian diet is rich in flavonoids, phytochemicals and antioxidants[15], and the intake in this population is higher than in omnivores[2].

Folic acid

The vegetarian diet is rich in folic acid, also called folacin or vitamin B9, a water-soluble vitamin present in dark green vegetables, legumes, among others, whose deficiency can lead to megaloblastic anemia[15].

Thus, the vegetarian diet is rich in this nutrient[15], and the intake is higher among the vegetarian and vegan population when compared to the omnivorous population[2]. However, when evaluated, the serum folic acid dosage showed no significant difference between vegetarians and omnivores[10].

Vitamin A or Retinol

Vitamin A is a fat-soluble vitamin, found in fruits and vegetables (tomatoes, carrots, spinach) in the form of carotenoids and in products of animal origin (liver, fish, milk) in the form of retinoids[15].

Children with vegetarian diets have a higher vitamin A intake than omnivores[8]; when the parents were evaluated, the result was repeated, with higher intakes by vegetarian parents than by omnivores[10]. Regarding the distribution of consumption based on precursors, we see that the lacto-ovo vegetarian diet is rich in carotenoids[15] with a higher intake when compared to omnivores[2], and retinoid intake was similar in both groups[8].

Vitamin B1 or thiamine

It is a water-soluble vitamin available in foods such as meat (predominantly pork), some fish (eg tuna), potatoes, vegetables, brewer's yeast and cereals (whole wheat, rice flour). Its deficiency can cause beri-beri and Wernicke-Korsakoff syndrome[15]. When measured in the pediatric population, it showed higher serum levels in Ghanaian vegetarians[8], however, there was no significant difference between the two Taiwanese groups[10].

Vitamin B2 or riboflavin

Another important water-soluble vitamin for children, riboflavin is present in milk, cereals, liver, fish, broccoli, peas and beans, and the deficiency affects the skin and mucous membranes[15]. Vitamin B2 levels were similar between vegetarians and non-vegetarians[10], however, in Ghana approximately 70% of vegetarian and omnivorous children do not ingest the recommended amount[8].

Vitamin B7 or Biotin

This water-soluble vitamin is present in products of animal origin (liver, milk and egg yolk) and, despite being present in soy flour, its bioavailability is variable. Deficiency causes scaly dermatitis, alopecia and neurological impairment[16].

A North American study evaluated lacto-ovo-vegetarian, vegan and omnivorous children, excluding those who used some type of vitamin supplement, collecting their food records and laboratory tests. To analyze the nutritional status of biotin, the serum level of biotin was collected and, as there is no urinary dosage of this vitamin, the substances linked to urinary avidin were measured in 24-hour urine, since avidin binds to biotin and can be detected in the laboratory, this test is a sensitive marker of the drop in biotin levels in animal studies[16].

The research results showed a slightly lower serum biotin level in vegetarians, however, this difference was not statistically significant. Regarding urinary excretion, the rate of excretion was higher among vegetarians, especially vegans. Finally, the study concluded that there is no harm to the nutritional status of biotin in vegetarians and vegans[16].

Some hypotheses have been raised to justify this higher urinary excretion: it could be that the biotin intake is higher and/or the bioavailability in the vegetarian diet is higher than in the omnivorous one, it could be that the vegetarian diet increases enteric synthesis and/or promotes absorption of biotin, or it may be that the flora alterations caused by the vegetarian diet increase the amount of other avidin-binding substances (such as bacterial metabolites and biotin precursors)[16].

Vitamin B12 or cobalamin

A water-soluble vitamin of greatest interest when discussing vegetarian diets, cobalamin is present in greater amounts in foods of animal origin (meat, milk and eggs), and in very small amounts in very few foods of plant origin[15], with unreliable bioavailability[5]. Therefore, vegetarians, especially children, may not consume adequate amounts[10].

Vitamin B12 intake by the vegetarian public in the studies on which this systematic review was based was, for the most part, below the recommended values, especially among vegans[15]. Only in one of the studies, carried out with the English child population, there was an intake above the recommended value (280%)[6].

In the laboratory evaluation of vitamin B12 deficiency, it should be borne in mind that the isolated dosage of the vitamin is not a good parameter for the diagnosis, and the collection of methyl malonic acid, homocysteine[5] and/or holotranscobalamin 2 [2 is recommended] . Studies have shown that the serum level of cobalamin is generally deficient in vegetarians, but also in the omnivorous population, with values below the reference in 50% of the omnivores participating in the cross-sectional study carried out with Ghanaian children[8].

Vitamin B12 deficiency can lead to megaloblastic anemia and neurological impairment[15]; it was seen that this deficiency is usually associated with iron deficiency[5] and can be masked by the high consumption of folic acid by vegetarian children[2].

Vegan infants who do not receive fortified foods should pay special attention to the composition of breast milk, as mothers with inadequate intakes will not provide sufficient amounts to their babies[6] and there is a drop in the levels of this vitamin during the first year of life for all infants[15], increasing the risk of developing a disability.

Therefore, vegetarian children should get vitamin B12 in alternative ways, such as consumption of fortified foods.

Vitamin B12 replacement is controversial in some respects; some recommend that every vegetarian should replace it[8,15]; some advise the replacement only for vegans[6]; there is also a recommendation for replacement depending on the intake or serum level, for example, in lacto-ovo vegetarians [2] ; and there are resolutions that allow the contribution from fortified foods and, if the necessary levels are not reached, then replacement is chosen[2,5]. In relation to younger children, as soy and rice-based formulas are usually supplemented, there is a recommendation to start replacement as soon as the formula is weaned[1]. The English prospective study found that the majority of vegan children were already receiving supplementation[7], which shows the concern of parents and pediatricians regarding the deficiency.

The dose used for replacement is 5 to 25mcg/day orally[5], and it can also be guided by age, as shown in Table 1 in the annex. When there are signs of deficiency, much higher doses are indicated[5].

Table 1. Recommended dose of vitamin B12 supplementation in vegans[8].

	Daily administration (mcg)	Weekly administration (mcg)
Children from 6 months to 3 years	5	
Children from 4 to 10 years old	25	1000 x3
Children from 11 years old	50	1000 x3

Vitamin C

Present mainly in citrus vegetables, vitamin C was ingested by vegetarians in greater amounts than omnivores in all studies that aimed to evaluate this nutrient[2,10,11,15]. Its deficiency causes scurvy and no case was reported in the articles used as reference.

Calcium

The main sources of calcium in the diet are dairy products, dark green vegetables, nuts and legumes[6].

Calcium intake was not similar in different studies, as 3 of the 6 studies that evaluated it showed a similar calcium intake between vegetarian and omnivorous children[8,10]; in two studies, vegetarians had a lower intake than omnivores[5,6]; and in the sixth study, lacto-ovo vegetarians had consumption similar to or higher than omnivores, while vegans had a lower intake[2]. What was most surprising is that in the 6 studies, a large part or the majority of the population had a calcium intake below the reference value. In the Polish study, only 54% of vegetarians and 62% of omnivores reached the required value[13]; in Ghana more than 90% of children in the 2 groups did not reach the recommended intake[8].

The absorption, availability and excretion of calcium also deserve attention, as the presence of phytate and oxalate hinder its absorption[2], a high sodium intake or acidosis (due to diets rich in meat, fish, grains and dairy products) lead to renal losses of calcium, while diets rich in potassium reduce losses[2]. Furthermore, some vegetables (broccoli, Swiss chard, kale, Chinese cabbage) have greater calcium availability than dairy foods[2], contrary to popular belief.

Vitamin D

Vitamin D is a fat-soluble vitamin and, in most studies, the intake was deficient[2,13] and the serum level was low in the vegetarian population, although the same was repeated with the omnivorous population[13]. In Poland, only approximately 40% of children (vegetarians and omnivores) had an adequate intake[13], in Spain the serum dosage was below the reference values for both groups[15]. Replacement is indicated for vegetarian children as well as for the others[16], either as prophylaxis or as replacement for those who have insufficient intake and sun exposure[6]. As vitamin D3 is of animal origin, an alternative for replacement in vegans is the use of D2, which is of plant origin[2].

Vitamin E or tocopherol

This fat-soluble vitamin is present in several foods of plant origin and also in eggs, and its deficiency can lead to neurosensory disorders[15].

It was seen that the vegetarian diet is rich in this nutrient[15], and in one of the studies the intake was higher by the vegetarian public[2], while in another there was no significant difference in relation to omnivores[10].

Iron

Iron intake by vegetarian children was higher[5], reaching 142% of the daily requirement for English children[6], or equal [8] for omnivores, however, iron from plant origin (non-heme) is less available when compared to iron from animal origin (heme)[7]. Furthermore, a diet rich in vegetables is consequently rich in oxalates, phytates and fibers, which hinder the absorption of iron[2,5]; the vegetarian diet is also rich in vitamin C, which helps in the absorption of iron[2], however, there are no conclusions as to whether this higher consumption of vitamin C is sufficient to compensate for the lower availability of iron[5]. Calcium and polyphenols also hinder absorption, while fermentation processes (such as those used to obtain tempeh and miso) increase iron availability[2]. Added to all these factors, it was seen that even with an intake rich in iron[7], vegetarians tend to have a lower serum level[8]; so there is a recommendation that vegetarians should consume 1.8 times the amount recommended for the general population[2].

Laboratory assessment of iron deficiency should not be performed using iron alone, as it is of low diagnostic significance[5]. Regarding iron dosage, results vary from one study to another; Taiwanese children had serum iron levels with no significant difference between vegetarians and omnivores[10], whereas among vegetarian Ghanaian children they had lower values than omnivores[8].

Ferritin was lower in vegetarian children in the five studies that evaluated it[3,8,10,11,15], despite being within the reference value in Taiwanese children[10], and in Ghanaian children having similar transferrin receptor dosage among omnivores. and vegetarians[8]. The only drawback in measuring ferritin is that it is also a proof of inflammatory activity, which may be increased in infectious episodes, giving a false-negative result, but to circumvent this problem, the Ghanaian study measured C-reactive protein (CRP) of the children evaluated, and positive CRP was used as an exclusion criterion for ferritin analysis[8].

Iron supplementation is indicated for patients with repercussions on ferritin[14], whether or not associated with anemia (hemoglobin below the reference value for age and gender), and therefore ferritin should be used regularly monitored in vegetarians[1].

Fortunately, despite the lower ferritin values, there was no impact on the hemoglobin levels of vegetarian children in 6 of the 7 studies that evaluated this point[2,6,7,8,10,15]. Only in a study carried out in Poland a higher incidence of iron deficiency anemia was seen among vegetarians (9.09% vs. 0% in omnivores)[11]. There was also no repercussion on the number of red blood cells, which were normal in the 2 studies that proposed to evaluate[10,6]. The assessment of Ghanaian children showed an incidence of 25% of anemia in the two groups studied, which may be a result of the higher incidence of sickle cell disease and/or worms due to worse sanitation conditions[8].

Iodine

Iodine is present in foods of marine origin (fish and crustaceans), milk, eggs and to a lesser extent in some vegetables, thus, the vegetarian diet usually has an iodine intake below the recommended level[15] . Currently, table salt is iodized, and its consumption ensures that reference values are reached, thus, only the consumption of salt eliminates the need for replacement[1]. Patients who do not consume iodized salt are at risk of deficiency[2] and should compensate with the intake of other foods fortified with iodine[5].

Magnesium

The main sources of magnesium are seeds and oilseeds, thus, the vegetarian diet is rich in this nutrient[15], and the intake is higher among vegetarians than among omnivores[2]. In the Polish study used as a basis for this work, vegetarian intake was on average 248 vs. 193mg/day of omnivores, and 100% of vegetarian children evaluated ingested the appropriate amount[13].

Potassium

Potassium is present in large amounts in fruits, vegetables and seeds, therefore, and the findings reported by the American Dietetic Association were compatible with this information, since the intake was higher among vegetarians when compared to omnivores[2].

Zinc

This nutrient is present mainly in oysters and meat and, to a lesser extent, in seeds and oilseeds. Thus, it was seen that the intake by vegetarian children may be lower compared to the general population[10,11,15]. However, this was not a consensus in all studies, as in some citations the values were similar[2]. Furthermore, zinc absorption is impaired by the presence of phytates and oxalates, which are present in the vegetarian diet in large amounts, as previously mentioned[3].

As for the zinc dosage, there was no difference between vegetarians and omnivores, being low in both groups[15].

Despite the aforementioned results, there was no evidence of intellectual or physical impairment in vegetarian children[6]. Therefore, serum levels should be regularly measured and replenished as needed[1].

Phosphor

The main sources of phosphorus, an important element for bone formation, are seeds and oilseeds, which explains the fact that the intake was similar between vegetarians and omnivores, and that 100% of the vegetarian children evaluated ingested the appropriate amount[13].

immunological aspects

A Polish study set out to assess the serum level of immunoglobulins in the pediatric vegetarian population. The study evaluated 18 omnivorous children and 22 vegetarians for at least 1 year, all healthy and without signs of immunodeficiency. Their serum immunoglobulin levels, food recall and clinical anamnesis were analyzed.

A correlation was shown between immunoglobulin levels and micronutrient intake, such as a positive correlation between IgM levels and caloric, zinc, copper and vitamin B6 intake, or a negative correlation between fat intake and IgA levels. Thus, as, the importance of a good nutritional status and protein intake for the proper functioning of the immune system was reaffirmed, since malnutrition leads to lower levels of immunoglobulins and the complement system and low protein intake leads to drops in IgG levels.

It was concluded that there is no significant difference between the immunoglobulin values (IgA, IgM and IgG) of vegetarians and omnivores. However, in vegetarians, the level of immunoglobulins is lower when there is iron deficiency (defined by ferritin below the reference value), which was not repeated in omnivores with iron deficiency. Thus, the balanced vegetarian diet did not affect the children's immunity, since there was no significant difference in the incidence of infections between vegetarians and omnivores[11].

In the evaluation of the white blood count series, also involved in the defense system, there was no difference between vegetarians and omnivores[6,10].

Other laboratory evaluations

In addition to the exams already mentioned, some analyzes were performed in the works and also worth mentioning, they are the dosage of uric acid, albumin, renal function and lipidogram.

There was no significant difference between the laboratory measurement of uric acid between vegetarians and omnivores, however, it was seen that there is a correlation between the values found in preschool children and one of their parents included in the Taiwanese study[10].

There was no difference between the laboratory dosage of albumin in vegetarians and omnivores, with the entire population studied with levels within the reference value, showing that there were no malnourished individuals in the sample; in addition, it was seen that there is a correlation between the values found in preschool children and one of their parents in the Taiwanese study[10].

In the evaluation of renal function, with creatinine and urea measurements, no changes were seen in relation to the reference values nor any significant difference between the vegetarian pediatric population and omnivores[10].

The serum level of total and LDL cholesterol is lower in vegetarian children than in omnivorous children[2,10], while HDL did not show a significant difference[10].

Physical and neurological development

In the analysis of the physical development of English vegan children, no changes were seen[6]; there is a study cited in the recommendations of the German Society of Pediatrics and Adolescent Medicine (DGKJ), in which vegetarian children performed better in relation to the reference population in tests involving resistance, while omnivores performed better in those involving physical strength[5].

English vegan children also did not show any impairment in terms of neurological development[6]; in another English study with vegan children, formal neurodevelopmental assessments were not performed, but all of them performed well in school and there were no reports of behavioral problems by their parents[7]. However, one should always be alert to these changes, since iron deficiency anemia and iron deficiency anemia may be associated with developmental delays and learning difficulties[8].

Benefits of the vegetarian diet

The population that chooses a diet without meat and/or without dairy products and eggs has a lower incidence of the most prevalent comorbidities of our time. Vegetarians have a lower incidence of hypertension, ischemic coronary disease, type 2 diabetes mellitus[10], dyslipidemia and colon and prostate cancer[14]. As a result, mortality within this group is also lower[10]. It is believed that this is due to the lower intake of saturated fat and cholesterol, as well as higher consumption of fiber, phytochemicals, whole grains and nuts[2].

recommendations

Below are the main recommendations for the pediatric vegetarian population.

Vegan infants who are not breastfed should be given soy- or rice-based infant formula; consumption of these formulas should be encouraged up to 6 years of age or older, as they are supplemented and are a good source of protein[1]; homemade or industrialized vegetable milks that do not fit the classification of infant formula cannot be the infant's main drink, they can only be used in the preparation of some food[15]. From 1 year onwards, opt for calcium-fortified vegetable drinks[15].

For the introduction of food in vegetarian infants, it is suggested to offer tofu, eggs, hummus, lentils, peanut butter, soy-based yogurts and vegetables rich in vitamins A and C. Some foods have a minimum age for introduction, they are: tahini that can be offered from the 6th month of life, honey and algae that should be offered after one year of age, and seeds such as chia and linseed that should be offered after one year of age, preferably crushed[6].

The health professional should pay attention to the intake of omega 3 and vitamin B12, especially with serial assessments of the level of vitamin B12 (preferably in association with the dosage of methylmalonic acid and homocysteine) and ferritin. Vitamin D and calcium also deserve attention, however, there are few recommendations that differ from the general population.

DISCUSSION

For numerous reasons, the number of vegetarians and vegans is growing, including within pediatrics, however, studies on the nutrition of this population are still scarce, health professionals are still unprepared for the proper monitoring and guidance of families, and this , added together, can harm children's health. Most of the available works are reviews and/or very old, with few options for original articles drawn from recent clinical studies. With the growth of the market for vegetarian products produced in order to replace those of animal origin and also fortified with nutrients, it is increasingly difficult to apply to the present day the conclusions of older studies. There are very few studies with the Brazilian population and this limits the knowledge about our population, which is very relevant when the subject in question is related to habits, food, which differs from one country to another, and exposure to the sun. (eg in the assessment of vitamin D).

This systematic review aimed to analyze anthropometric and nutritional differences in vegetarian children, in order to improve the care provided by the professionals involved in the production of this work, as well as those who will have this material for consultation.

Some data were constant in most of the studies used as a reference for this work, such as: vegetarian children have lower levels of ferritin, but no greater risk of anemia or neurological development impairment; the anthropometry of children who do not eat meat is similar to that of omnivorous children and is within the reference values, despite the tendency to lower weight and height; there was no significant difference in caloric intake between the groups, and there is a lower intake of fat, which results in a reduction in obesity and cardiovascular disease rates; there is greater fiber intake; there is a lower intake of omega 3, present in small amounts in foods of plant origin; there is a deficiency in the intake of vitamin B12 in the vegetarian population, especially vegans, which requires frequent monitoring of serum levels of tests indicative of deficiency (such as methylmalonic acid and homocysteine); and, finally, there is a lower incidence of several diseases in vegetarians, such as arterial hypertension, type 2 diabetes mellitus, coronary artery disease, dyslipidemia, colon and prostate cancer, and, consequently, lower mortality.

As for lower weight and height, the possibility was raised that this may be due to the fact that vegetarian children are breastfed for longer than omnivores and, consequently, receive less infant formula, and it is known that the use of infant formula is associated with higher rates of obesity. However, there are other aspects of vegetarian nutrition that may justify the trend towards lower anthropometry, such as higher intake of fiber, vegetables, phytochemicals and whole grains, and lower intake of fat, especially saturated fatty acids and cholesterol. Higher protein intake by omnivores may also be related to this, as excess protein in early childhood is associated with overweight. Another relevant question is that, if caloric intake is similar between vegetarians and omnivores, could the higher incidence of obesity in omnivores be related to the quality of this diet and lifestyle? Work could be done to investigate which of these factors, in addition to possible others, has the greatest influence in determining growth.

Children have a greater demand for energy and nutrients, as well as requiring greater care, when compared to the adult population, which reinforces the need to expand the number of researches and works on this subject, as well as to include vegetarian nutrition in classes of universities and pediatric residency services.

Adolescents also demand greater care, because, due to pubertal development and the increase in growth velocity, there is an increase in the need for nutrients at this stage[15]. Older studies showed the occurrence of menarche later in vegetarian girls[14], which may be due to a lower percentage of body fat and a tendency to lower weight[7], however, recent studies have not shown this difference anymore. Considering the high incidence of eating disorders and self-image in the population, especially adolescents, attention should be paid to the risk that young people choose a vegetarian diet in order to lose weight in this context and that this goes unnoticed in the eyes of follow-up professionals.

Still in relation to adolescents and anthropometric variables, we raise the following question: if vegetarians tend to have a lower weight, is there greater difficulty in gaining muscle mass during physical activities that can be performed in adolescence?

Another question raised during our research was: although there is no greater risk of infections in vegetarian children, is there an increased risk of autoimmune diseases, as well as in those with primary immunodeficiency, due to lower immunoglobulin levels associated with reduced ferritin in vegetarians?

The German Society of Pediatrics and Adolescent Medicine, American Dietetic Association, Association of Nutritionists of Canada and the Spanish Pediatric Association advise that a balanced and well-planned vegetarian diet is capable of allowing adequate weight, height and nutritional growth in children. Unlike the French Pediatric Group of Hepatology, Gastroenterology and Nutrition, which states that a vegetarian diet is not recommended for babies due to the risks of nutritional deficiencies. Regardless of whether the diet is recommended or not, the number of vegetarians is on the rise and we need to be prepared to follow the patients, support the family, guide the diet in order to avoid nutritional deficiencies and, in their presence, know how to treat and teach the preparation and combinations of foods that favor taste and nutrition.

CONCLUSION

From the systematic review presented above, we can conclude that a balanced and well-planned vegetarian diet is capable of allowing adequate weight, height and nutritional growth for children, however, routine attention should be paid to the intake and levels of vitamin B12, omega 3 and ferritin in these patients. It is the role of the health professional to guide and support the family so that this adequate diet is achieved and, associated with good habits, lead the child to a good anthropometric and neuropsychomotor development, in addition to maintaining the same health controls that any other child would have.

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Declaration of conflict of interest

The author(s) declare that there is no potential conflict of interest with respect to the research, authorship and/or publication of this article.

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