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Title	Risks and benefits of vegan and vegetarian diets in children
Authors	Kiely, Mairead E.
Publication date	2021-01-28
Original Citation	Kiely, M. E. (2021) 'Risks and benefits of vegan and vegetarian diets in children', Proceedings of the Nutrition Society, 80(2), pp.159-164. https://doi.org/10.1017/S002966512100001X
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.1017/S002966512100001X
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Download date	2026-09-09 15:16:58
Item downloaded from	https://hdl.handle.net/10468/11057

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Proceedings of the Nutrition Society (2021), **80**, 159–164 doi:10.1017/S002966512100001X
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First published online 28 January 2021

Nutrition Society Live 2020 was held virtually on 14–15 July 2020

Symposium three: Physiological determinants for protein requirements

Risks and benefits of vegan and vegetarian diets in children

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In parallel with increased public awareness of the health and environmental benefits of consuming a plant-based diet, the numbers of people who identify as vegan has increased sharply. The question of whether vegetarian and vegan diets are appropriate for children is a longstanding and unresolved controversy. The more restrictive the diet and the younger the child, the greater the risk of nutritional deficiency. Nutrients of potential concern are protein quantity and quality, iron, zinc, selenium, calcium, riboflavin, vitamins A, D, B_{12} and essential fatty acids. Although intakes and status of some nutrients (e.g. vitamin D and iron) are low in many children, vegan children are particularly susceptible due to inadequate supply and/or excess dietary fibre as well as other components that limit bioavailability. Although position papers from North America state that well-planned vegetarian and vegan diets, supplemented appropriately, are suitable for all life stages, European statements include strong recommendations to parents that vegan diets should not be adopted by children without medical and dietetic supervision. Case histories of malnutrition and serious harm persist, including irreversible neurological damage due to vitamin B_{12} deficiency among un-supplemented children. The evidence available to evaluate the nutritional appropriateness of vegetarian diets for children is inadequate and dated. Although nutritionally adequate vegetarian diets are more easily achieved, successful provision of a complete vegan diet for a young child requires substantial commitment, expert guidance, planning, resources and supplementation.

Vegan diet: Vegetarian diet: Child: Infant: Paediatric nutrition

Consumption of plant-based diets has been a safe and nutritious practice for thousands of years. Up to a third of the population of India does not consume meat or fish for religious reasons and the influence of ancient Greek philosophers, who believed that human subjects have a responsibility to protect animals, continues to the present day[1]. Alongside health, environmental and animal protection are major reasons for a rise in vegetarianism, particularly veganism, in recent years[1]. According to the Vegan Society, the numbers of practicing vegans in the UK has increased 4-fold over the past 5 years, from 150 000 in 2014 to 600 000 (1·16 % of the population) in 2019. On the basis of similar steep increases in veganism in the USA, the Economist named 2019 'The Year of the Vegan'[2], citing that one-quarter of all millennia (25–34-year olds) reports practicing a vegetarian or vegan diet.

Due to their high requirements for growth and development and limited intake capacity, young children are often reported as having inadequate nutritional intakes and status[3,4]. A longitudinal study among thirty-nine young vegan children published in the 1980s[5] showed that provided sufficient care is taken, a vegan diet can meet the nutritional requirements of the preschool child. The study concluded that 'there are adequate and inadequate vegan diets. Malnutrition can arise because

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https://doi.org/10.1017/S002966512100001X Published online by Cambridge University Press

of ignorance and misinformation'[5]. Sanders also pointed out that the widespread publicity of individual case studies of malnutrition on diets labelled as vegan can lead 'many health professionals to condemn vegan diets as being nutritionally inadequate'. The risk of harm to young children of restrictive diets is very real, and there are multiple case histories in the modern literature of failure to thrive, nutritional rickets and severe developmental delay caused by inappropriate vegan diets[6–9]. Most cases are attributable to inaccurate information or mistrust of the medical profession, causing a failure to provide adequate nutrition[5–8].

The aim of the present paper, arising from a presentation by the author at the Nutrition Society Summer Meeting of 2020, is to discuss the nutritional appropriateness of vegetarian and vegan diets for children. Potential health benefits are proposed and risks are discussed in the context of the dietary restrictions and available evidence. Recent position papers from North America and Europe on the suitability of vegetarian-type diets in children are compared. The present paper is not a systematic review, but an evaluation of available evidence for the purposes of public health nutrition and clinical practice and to identify knowledge gaps.

Vegetarian and vegan diets defined

Typically, vegetarian diets are defined on the basis of their exclusions, but a more positive approach also considers the diversity of included foods, as, similarly with all diets, the quality of vegetarian diets is defined by the foods consumed on a regular basis. Lacto-ovo-vegetarianism excludes meat and fish but includes dairy, eggs, honey and a wide variety of plant foods. Lacto-vegetarians exclude eggs and while ovo-vegetarians do consume eggs, they exclude dairy foods. Although it includes a wide variety of plant foods, veganism excludes all animal products, namely meat, fish, dairy, eggs and honey, as well as foods that use ingredients derived from processing of muscle or dairy foods, such as gelatine and rennet. Macrobiotic diets vary from being strictly vegetarian, with cereals, pulses, vegetables, seaweed and soy products, avoiding dairy, eggs and some vegetables, to more liberal options, including fish in some cases. Not considered here are the raw food diet, consisting of mainly raw vegetables, fruits and seeds, milk and eggs and the fruit diet of fresh and dried fruits, seeds and some vegetables[10].

The more restrictive the diet and the younger the child, the greater the risk[11]; nutrients of potential concern are usually protein quantity and quality, iron, zinc, selenium, calcium, vitamins A, D, B_{12} and essential fatty acids, namely DHA or α-linolenic acid[10,11]. Although some of these nutrients (e.g. vitamin D and iron) are considered at risk nutrients in many children[3,4], there are additional aspects particular to vegetarian and vegan children that may exacerbate their vulnerability, including their relatively higher dietary fibre intake and the higher intake of food components, e.g. phytates and oxalates, that limit nutrient bioavailability[11].

Health benefits of vegetarian diets

There are few data on the health benefits of vegetarian diets among children. Among adults, Appleby and Key[12] investigated associations of vegetarian diets with non-communicable diseases, using data from eight prospective cohort studies of almost 280 000 participants, of whom almost a third classified as vegetarians. The studies were conducted between the 1950s and 2007 in the United States and Europe, with a strong representation of Seventh Day Adventists in the US cohorts. Acknowledging the overall lack of data available, its heterogeneity and the imprecise classification of vegetarian and vegan subjects, the authors concluded that vegetarians appear to have similar mortality rates relative to the general population and a lower risk of IHD than non-vegetarians from a similar background. The risk for all cancer sites combined was slightly lower in vegetarians than nonvegetarians. There were also indications that vegetarians have lower risks for diabetes, possibly related to a lower prevalence of obesity, and were less likely to be diagnosed with diverticular disease or cataract. Due to insufficient data, it was not possible to disaggregate risks for vegans. With regards to bone health, the data were confounded by habitual calcium intakes. An analysis of the EPIC-Oxford cohort comparing fracture risk among meat eaters, fish eaters, vegetarians and vegans from the same team[13] showed that the higher apparent fracture risk in vegans was driven by those with calcium intakes below about 500 mg/d. Previous reports of lower bone mineral density and higher fracture risk among vegetarians compared with meat-eaters have been recently challenged by Karavasiloglou *et al.*[14], who reported that, with the exception of the lumbar spine, bone mineral density among vegetarians and meat-eaters in National Health and Nutrition Examination Survey was not different when anthropometry was included in the models. The accompanying editorial[15] cautioned about the lack of specific data on vegans within the vegetarian subgroup and the continued need for prospective data in well-characterised studies to identify problems and inform policy. From the perspective of child health, studies among younger age groups, adolescent females and young women should be prioritised.

Among children and adolescents, Sabaté and Wien[16] summarised several studies of vegetarian diets focused on growth and body weight status and noted that vegetarian children were leaner and taller in adolescence compared with omnivorous children, with potentially healthier blood lipids. Many of the studies in this review[16] relied on Adventist subjects in the USA, and while the authors conceded that nondietary factors, including physical activity, smoking and educational level, could be influential in these studies, the potential impact of meat avoidance and a greater intake of plant foods should not be discounted in obesity prevention.

What is the evidence base for adverse effects of vegetarian diets in children?

In 2017, Schürmann and colleagues[17] conducted a systematic review to evaluate the dietary intake, nutritional

https://doi.org/10.1017/S002966512100001X Published online by Cambridge University Press

and health status of vegetarian infants, children and adolescents in industrialised countries. Although case reports were excluded, observational and comparative studies were documented, including participants from birth to 18 years of age, with the exception of exclusively breast-fed infants. A description of the vegetarian diet being followed was required for inclusion, as well as data on dietary intake and nutritional and/or health status. In total, twenty-four publications from sixteen study populations qualified; nine were conducted after 2000, of which seven were from Poland (five papers from the same study population). The remaining fifteen publications were reported in the 1990s (ten studies) and 1980s (five studies). There were two studies in infants or toddlers and two studies of vegan diets, one of which was prospective[5]. Seven publications, including five of the six with a sample size >100, were conducted in children from Seventh Day Adventist communities in the USA, and studies were split evenly by cross-sectional and prospective study design. The heterogeneity of the study outcomes reported, together with generally sketchy dietary characterisation precluded the authors from making any firm conclusions on the benefits or risks of current vegetarian diets with respect to nutritional or health status of children[17]. In general, studies reported low intakes and status of vitamin B_{12}, iron and vitamin D and low calcium intakes were common. Only the vegan children were receiving supplements[17].

More recently, the VeChi diet study from Germany[18] compared macronutrient intakes and paediatrician or parental-reported anthropometric data in 1–3 year old children classified as omnivore, vegetarian or vegan. Based on 3-d weighed dietary records, all children had largely similar macronutrient intakes, with adequate protein provision. Although group means did not differ for height and weight outcomes, there were more outliers in the vegan group; 3·6 % vegan children were classified as stunted, according to the WHO child growth standards, or wasted. In contrast, 23·2 % omnivorous children *v.* 18 % vegan and vegetarian children were classified as overweight or at possible risk of overweight[18].

Due to its heterogeneity in terms of the inclusion of both plant and animal foods, children following macrobiotic diets were excluded from the Schürmann review[17]. In one of the few detailed prospective longitudinal studies, Dagnelie and van Staveren[19] followed fifty-three macrobiotic and fifty-seven omnivore infants aged 4–18 months, with age ranges overlapping in three cohorts from 4–10, 8–14 and 12–18 months. The outcomes of the studies were sobering: dietary deficiencies of energy, fat and protein were noted due to lack of suitable breast milk replacement after weaning; for example, dietary fat decreased from 37 % energy at 6–8 months to 17 % energy at 14–16 months, because fat from breast milk was not replaced after weaning. Dietary fibre intake was high (up to 19 g/d before 18 months) and low calcium (280 mg/d), riboflavin (0·4 mg/d) and B_{12} (0·3 μg/d) intakes were confirmed by low B_{12}, iron and riboflavin status as well as vitamin D deficiency (20/25 had 25-hydroxyvitamin D concentrations <20 nmol/l in March, which is consistent with a high risk of nutritional rickets, particularly with low calcium intakes). In winter, 90 % macrobiotic children had nutritional rickets and there was marked growth failure in weight, length, head circumference, weight for length and arm circumference, with no gains in fat or muscle mass of arms over the previous year. Global developmental delay, particularly of gross motor skills was noted in macrobiotic children, who were 3 months late to walk on their own. The authors concluded that similar longitudinal studies were required among other vegetarian populations, including representative samples, omnivorous control groups, biochemical, dietary and anthropometric assessment and validated clinical outcomes, without which conclusions could not be drawn on the nutritional adequacy of vegetarian-type diets in children. To date, such studies have not been reported.

There are many case histories, such as those reported by Guez *et al.*[9] and Farella and colleagues[6] of infants at particular risk of malnutrition, growth failure and developmental delay due to misinformed dietary practices, including inappropriate infant feeding[6] and lack of timely and appropriate supplementation[9]. Lemale *et al.*[20] conducted a survey among French paediatricians from 2005 to 2015, which identified thirty-four children who suffered clinical consequences of prolonged consumption of non-dairy beverages during infancy. Consequences included growth failure, fatigue, malnutrition including oedema, hypocalcaemia, seizures, anaemia, hyponatraemia, metabolic bone disease secondary to calcium and vitamin D deficiency, and in one case, death[20]. The most severe consequences were observed in children who were introduced to non-dairy drinks before the age of 4 months. Of note, 59 % of these children had not received childhood immunisations and in follow-up visits of recovering children, about one-third of parents were displeased about providing nutritionally appropriate infant diets[20], indicating distrust of modern medicine.

International position statements on vegetarian diets in children

North America

The comprehensive 2003 position statement of the American Dietetic Association and Dietitians of Canada[21] concluded that 'appropriately planned vegetarian diets are healthful, nutritionally adequate, and provide health benefits in the prevention and treatment of certain diseases'. The statement provided a food-based justification for identifying nutrients of concern, including protein, iron, zinc, calcium, iodine, vitamins A, D, B_{12}, riboflavin and essential fatty acids, specifically DHA, and offered dietary strategies to meet intake guidelines for these nutrients. Progressing through the life-course, the statement provided specific advice for each life stage to meet nutritional requirements and listed resources for additional information.

Taking a documented evidence-based approach, the 2009 position statement of the American Dietetic Association[22] did not deviate in any regard from the 2003 statement[21] either in its structure or final

https://doi.org/10.1017/S002966512100001X Published online by Cambridge University Press

conclusion, that 'appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes'. However, although general advice for specific life-stages was almost identical to the earlier document, the dietary strategies section was omitted and vitamin A and riboflavin were not listed among the nutrients of concern[22].

Following the 2009 statement, the Canadian Paediatric Society[23] acknowledged that the concept of a well-balanced, appropriately supplemented vegetarian diet is supported by evidence and endorsed by expert bodies. However, Amit and colleagues introduced a note of caution with reference to very restrictive diets including vegan diets, which could place children at risk of significant medical consequences if specific nutrition needs were not met. The lack of data in vegan children was highlighted as a cause for uncertainty in relation to growth patterns, energy and protein intakes[23]. Nonetheless, age-specific increases in protein requirements for young vegan children were proposed to counteract lower plant protein digestibility, although the primary source[24] did not provide supportive evidence for these increases. Specific recommendations for supplementation of pregnant and breast-feeding mothers were extended to include calcium, in addition to vitamin D, folic acid, B_{12}, iron and linolenic acid[23]. The paper ended with a strong recommendation to refer all vegan children to a clinical nutritionist to monitor growth and development.

In 2016, the American Academy of Nutrition and Dietetics published its revised position paper on vegetarian diets[25], reiterating its conclusion statement from 2009, with an additional note endorsing the environmental benefits of plant-based diets. Specific advice for vitamin B_{12} as an essential fortification/supplement requirement for vegans was provided, but recommendations for other at risk nutrients were less definite. Similarly to the Canadian Paediatric Society paper[23], potential increases in protein requirements among young vegan children (up to 35 % in toddlers) were raised[25] without reference to the primary data.

Europe

During the same year, the German Nutrition Society[26] published a position paper on vegan diets, outlining the challenges of meeting nutrient requirements, particularly vitamin B_{12}, and urging physician/dietitian supervision during the growing years. Mandatory supplementation with B_{12} was emphasised and substitute foods to counteract the risk of several nutritional deficiencies were outlined across seven food groups[26]. In a review of B_{12} requirements during pregnancy, lactation and childhood, Pawlak[27] commented on the apparent contradictions between the German and US 2016 statements[25,26], which deviated in their tone and in the clarity of advice provided, both with regard to supplementation, dietary strategies for vegans in particular, medical/dietetic supervision required and responsibilities of parents. This became a crucial point of difference.

Following the German Nutrition Society statement, the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition position paper on complementary feeding[28] included a dedicated section on vegan and vegetarian diets, which emphasised the need for particular care during complementary feeding, including regular medical and expert dietetic supervision and an onus on mothers to receive and follow nutritional advice from the recommended experts. Although the theoretical possibility of meeting nutrient requirements for pregnancy, lactation and infancy was recognised, and the nutritional advice was similar to statements previously discussed, the harm resulting from a failure to follow this advice was described in detail[28]. Again, consequences from B_{12} deficiency due to lack of supplementation, including neurological damage and potential death, were firmly placed within the remit of parental responsibility.

In line with European Society for Paediatric Gastroenterology, Hepatology, and Nutrition and the German Nutrition Society, the German Society for Paediatric and Adolescent Medicine[11] took a cautionary stance against restrictive diets in childhood on the basis that 'the stricter the diet, the greater the risk' and recommended a balanced omnivorous diet, including plenty of plant foods, as the preferred choice for children. According to Rudloff and colleagues, carers were advised to be attentive to the 'intake and status of iron, zinc, iodine, DHA, calcium, protein and calories in order to prevent serious clinical complications such as growth faltering, anaemia or neurological damage'. For vegans, vitamin B_{12} supplementation was strongly advised for pregnant and breast-feeding women and children, alongside ongoing paediatric and dietetic supervision of growth and development[11]. The Spanish Paediatric Association[29] expressed a preference for omnivorous and lacto-ovo-vegetarianism over vegan diets in children, and advocated obligatory B_{12} supplementation and continuous monitoring of the risk nutrients. Taking a yet stronger stance, the French-Speaking Paediatric Hepatology, Gastroenterology and Nutrition Group[30] summarised its position by stating that a vegan diet is 'not recommended for infants, children, and adolescents due to the risk of multiple nutritional deficiencies that are inevitable in the absence of supplements'. Systematic supplementation of B_{12}, vitamin D, calcium and algal DHA was recommended alongside the consumption of iodised salt and continuous monitoring of serum ferritin and plasma zinc concentrations, under professional supervision[30].

With a focus on the content relevant to infants and young children, the two consistent, stand-out messages from these position statements, drafted within the same time-frame and based on largely on the same evidence, are that vitamin B_{12} should be provided to vegan mothers and their children for the prevention of irreversible neurological damage and that professional supervision of growth and development in vegan children is required

https://doi.org/10.1017/S002966512100001X Published online by Cambridge University Press

due to the high risk of inadequate intakes of protein, iron, zinc, calcium, vitamin D and DHA[11,23,25,26,28–30]. The tone of the European statements, over the past 3 years in particular, appears to reflect a growing disquiet about veganism among young children due to the high risks involved and the need for constant supervision[11,26,28–30]. There is a wide diversity between European countries in paediatric care; a European Academy of Paediatrics survey of the primary paediatric care system[31] showed that over 40 % EU countries have general practioner-led care with a median of 4-month paediatric training. It is a valid concern that without obligatory paediatrician-led follow-up, early detection of developmental delay or growth failure among vegan children may be unlikely in reality. Problems of inadequate paediatric training in primary care are exacerbated by a lack of nutrition education during medical school[31].

Several vegetarian and vegan societies have produced useful guidance documents for families to facilitate the provision of diets that support healthy growth and development of children; for example, the British Dietetic Association and the Vegan Society have been working together since 2014 to provide advice on a healthy vegan diet. Based on a Mediterranean style vegetarian diet, Baroni and colleagues[32] devised the VegPlate Junior to support health care professionals in advising vegetarian parents.

Conclusions

The evidence basis for evaluating the nutritional appropriateness of vegetarian diets for children is inadequate, with problems including sampling bias, poor research quality, varied, uncharacterised diets, self-reported anthropometry and incomplete nutritional assessment. Despite the high quality of some early studies, publications are largely dated and we cannot assume that observations from the 20th century are applicable to young families today. The food industry has responded to massive increases in demand for vegetarian foods by designing plant-based meat and dairy substitutes, with appealing sensory attributes and variable nutritional profiles. Some of these products have been criticised for being highly processed with unhealthy nutritional profiles, including high amounts of sugar, salt and saturated fats[26]. However, smart new foods may offer an opportunity to meet the nutritional requirements of vegetarian and vegan consumers, with appropriate fortification and healthy food composition[33]. Therefore, contemporary, high quality prospective studies are needed with appropriate control groups and comprehensive nutritional profiling to examine the potential impact of vegetarian and vegan diets on immediate and long-term health outcomes among women, infants and children[34].

Although parental responsibility is more strongly articulated by European organisations, position statements on either side of the Atlantic are basically aligned in terms of the core points: (1) nutritionally adequate lacto-ovo-vegetarian diets are relatively easy to provide; (2) the risks of nutritional deficiencies and adverse consequences lie with vegan children in particular, especially younger children, and when guidance, monitoring and supplementation are inadequate or inconsistent; (3) while vegan diets are technically feasible, the successful provision of a nutritionally complete vegan diet for a child requires substantial commitment, expert guidance, planning, resources, supervision and supplementation.

Financial Support

None.

Conflict of Interest

None.

Authorship

The author had sole responsibility for all aspects of preparation of this paper.

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Proceedings of the Nutrition Society

https://doi.org/10.1017/S002966512100001X Published online by Cambridge University Press