Role of Dietary Factors and Food Habits in the Development of Childhood Obesity: A Commentary by the ESPGHAN Committee on Nutrition

ESPGHAN Committee on Nutrition: [*3]*Carlo Agostoni,* [†]*Christian Braegger,* [‡]*Tamas Decsi,* [§]*Sanja Kolacek,* [||3]*Berthold Koletzko,* [¶]*Walter Mihatsch,* [#]*Luis A. Moreno,* [**]*John Puntis,* [††1]*Raanan Shamir,* [‡‡]*Hania Szajewska,* [§§2]*Dominique Turck, and* [||||]*Johannes van Goudoever*

ABSTRACT

This Comment by the Committee on Nutrition of the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition aims to provide a summary of the role of nutrition-related factors on obesity prevention in children ages 2 to 18 years. This Comment emphasizes that dietary interventions should be incorporated into a multidisciplinary strategy for obesity prevention. No single nutrient has been unequivocally associated with the development of obesity. Methodological limitations in study design and the complex nature of obesity must be taken into account when interpreting the association with reported dietary factors. Energy intake should be individually determined, taking into account energy expenditure and growth. Preferential intake of slowly absorbed carbohydrates and limiting the ingestion of rapidly absorbed carbohydrates and simple sugars should be promoted. No specific recommendations for macronutrient intakes to prevent obesity can be made. Plant foods can be used as the main food contributors to a well-balanced diet with adequate monitoring of nutrient intake. Plain water should be promoted as the main source of fluids for children instead of sugar-sweetened beverages. Children should eat at least 4 meals, including breakfast, every day. Regular family meals should be encouraged. Regular consumption of fast food with large portion sizes and high energy density should be avoided. Healthy food options should be promoted for snacking. Food portion sizes should be appropriate for age and body size. Nutrition and lifestyle education aimed at the prevention of obesity should be included in the routine care of children by health care professionals.

Key Words: dietary factors, food habits, health education, obesity, prevention

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Obesity is the most prevalent nutritional disorder among children and adolescents throughout the world (1,2). Notwithstanding recent reports suggesting a levelling off of the prevalence of obesity in some countries (3–5), the burden of paediatric obesity for society is still high (6–8). In addition to short-term complications such as psychosocial disturbances or orthopaedic problems, the origins of potential long-term metabolic consequences are also identifiable in many obese children (9). It is well established that obesity is a multifactorial disease in which genetic as well as psychological and environmental causative factors are implicated, with diet and physical inactivity looming large.

The focus of this comment is to assess the role of dietary factors and food habits in the prevention of obesity in childhood. For the roles of physical activity and sedentary behaviour, we refer readers to available reviews and position papers (10–13). The treatment of obesity is also beyond the scope of this Comment. For the role of dietary interventions in the treatment of obese children, we refer readers to a recent Cochrane review (14). Finally, the role of early nutrition in obesity development is not covered because nutrition during the first year of life has been extensively discussed in 2 recent comments published by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition Committee on Nutrition (15,16). In summary, it was stated that the potential for breast-feeding to contribute to reduction of later obesity should be explored in more detail, and that the available evidence on how complementary feeding influences later obesity risk is not conclusive.

This Comment aims to provide a state-of-the-art summary on the role of nutrition-related factors that may contribute to the development of obesity in children ages 2 to 18 years. This Comment also provides recommendations on healthy nutrition patterns with the potential to decrease obesity risk to be promoted by paediatricians and other health care professionals.

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From the *Department of Maternal and Pediatric Sciences, University of Milan, Fondazione IRCCS Ca' Granda—Ospedale Maggiore Policlinico, Milan, Italy, the †University Children's Hospital, Zurich, Switzerland, the ‡Department of Paediatrics, University of Pecs, Pecs, Hungary, the §University Hospital ''Sister of Mercy,'' University Children's Hospital Zagreb, Zagreb, Croatia, the ||Dr von Hauner Children's Hospital, University of Munich Medical Centre, Munich, Germany, the ¶Department of Paediatrics, Deaconry Hospital, Schwaebisch Hall, Germany, the #Escuela Universitaria de Ciencias de la Salud, Universidad de Zaragoza, Zaragoza, Spain, the **Leeds General Infirmary, Leeds, UK, the ††Schneider Children's Medical Center of Israel, Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel, the ‡‡Medical University of Warsaw, Warsaw, Poland, the §§Jeanne de Flandre Children's Hospital, Lille University Faculty of Medicine, Lille, France, and ||||Pediatrics, VU University Medical Center, Amsterdam, The Netherlands.

Address correspondence and reprint requests to Dr Luis A. Moreno, E.U. Ciencias de la Salud, Universidad de Zaragoza, C/Domingo Miral s/n, 50009 Zaragoza, Spain (e-mail: lmoreno@unizar.es).

[1] Committee Chair; [2] Committee Secretary; [3] Guests.

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ENERGY

Although the gap between energy input and energy expenditure plays a major role in the development of obesity (17), energy balance is far more complex than this model suggests (18). There are paradoxical reports of reduced energy intakes in children who were already obese and/or overweight, pointing to the importance of energy expenditure (19) and the possibility of reverse causation. Reports on preventive interventions have also emphasized the role of a regular decreased daily energy intake (ranging from 100 to 150 kcal/day) to counterbalance the energy gap and its possible role in obesity (20,21). Lack of consistency between observations has raised methodological questions with regard to the adequacy of dietary surveys, given the trend to underreport dietary intakes in obese subjects, and the possible role of nutrient imbalances (eg, the quality of fats vs their quantity) (22,23). Because fats are the major source of energy, inaccurate recording of intake could lead to as much as a 2-fold error when determining their contribution to overall energy intake. Nevertheless, examining the differences in energy intakes and/or energy balance should be given priority in studies on the dietary determinants of overweight and obesity.

Recommendation Considering the multiple factors involved in energy balance, energy intake should be individually determined, taking into account energy expenditure and growth.

MACRONUTRIENTS

The role of particular macronutrients (as total or relative percentage of energy intake) in the aetiology of obesity is poorly understood. This is due in part to the complex interrelation between dietary carbohydrate (CHO), protein, and fat, given that when the intake of 1 macronutrient changes, the intake of the other 2 also changes as a consequence.

Carbohydrates and Fibre

The intake of simple CHO has been proposed to be associated with adiposity development, whereas slowly absorbed CHO (low glycaemic index) could be protective (24). In adults, observational studies suggest a possible relation between consumption of sugar-sweetened beverages and body weight, but there is insufficient supporting evidence from randomised controlled trials of adequate size and duration (25).

Rapidly digested carbohydrates produced lower satiety in normal-weight and obese children (26), whereas low-glycaemic-index foods eaten at breakfast had a significant impact on food intake at lunch, when intake was reduced after low- compared with after high-glycaemic-index breakfasts (27). Accordingly, the independent roles of breakfast and CHO-based foods within breakfast in satiety need to be defined to develop obesity prevention strategies (28).

Buyken et al (29) prospectively examined whether dietary glycaemic index, glycaemic load, added sugar intake, or fibre intake between ages 2 and 7 years is associated with the development of a particular body composition, and if so, to ascertain whether these associations are modified by meal frequency. They observed that neither dietary glycaemic index nor glycaemic load or added sugar intake appeared to significantly influence changes in body composition. It is possible that potential benefits associated with increasing fibre intake throughout childhood could be limited to toddlers with a lower meal frequency (29).

Recommendation The ingestion of slowly absorbed CHO should be promoted, while limiting the supply of rapidly absorbed CHO and simple sugars.

Fats

Fats are the main energy contributors to the diet on a volume intake basis: They are twice as energy dense as carbohydrates or proteins, and the energy cost of storage of the energy contained in fats is about one-tenth that for carbohydrates or proteins (30).

Enhanced percentage fat intake was significantly related to increased relative body weight (31), body fat mass (32), and body fat content (33) in large groups of children. However, equivocal results were found when groups of children were subdivided according to sex: significant positive correlations were found between dietary fat intakes and body fat mass in boys, but not in girls (3,34,35). It is important to note that other observational studies failed to find a relation between fat intake and the development of obesity (36,37).

The only available intervention study suggests that modification of fat intake may decrease the risk of obesity. When infants were randomly assigned at the age of 7 months to dietary counselling with the aim of reducing total fat and substituting unsaturated products instead of saturated fats, the proportion of overweight girls was significantly lower in the intervention group than in the control group when followed up at the age of 10 years (38).

Experimental evidence suggests that polyunsaturated fatty acids of the omega-6 series may promote both adipogenesis in vitro and adipose tissue development in vivo in rodents during the gestation/lactation period (39). Small observational studies found significant differences in plasma linoleic acid, arachidonic acid, and the sum of omega-3 polyunsaturated fatty acids between obese and nonobese children (40,41), but these data do not allow inferences on causality considering also the potential role of the subinflammatory status associated with obesity (42).

A review concluded that the role of dietary fat types as early determinants of childhood obesity is poorly understood (43). The potential for medium-chain triglycerides, conjugated linoleic acid (CLA), and omega-3 long-chain polyunsaturated fatty acids to modulate food intake has been explored (44), and supplementation of CLA was recently reported to significantly attenuate body fat deposition in overweight or obese prepubertal children (45). However, safety and efficacy of such interventions require careful scrutiny in the paediatric age group (46,47).

Further paediatric data are needed on the effects of total fat consumption and the potential role of dietary fat quality and composition on the development of childhood obesity.

Recommendation It is likely that total fat intake and specific dietary lipids play a role in the development of obesity. However, the paucity of available data does not support recommendations on fat quantity and quality in relation to obesity prevention.

Proteins

Dietary proteins and specific amino acids (particularly arginine, alone or in combination with lysine) have been shown to stimulate the somatotropic axis and may thereby influence body composition (48,49). Growth hormone (GH) plays an important role in reducing fat mass, with studies showing increased lipolysis and decreased fat mass after GH administration (50).

Agostoni et al (51) suggested that a positive correlation between high protein intake and later obesity occurs mainly in populations with protein intake higher than 15% to 16% of total energy intake. When compared with a low-protein, high-fat intake diet, a high-protein, low-fat diet was associated with an earlier adiposity rebound (defined as the rise in body mass index [BMI] curve normally occurring at 5–7 years of age), which has been

shown to be associated with the development of obesity (52). The analysis of data from the German DONALD study suggests that animal but not vegetable protein intakes in early childhood may play a role in later overweight and adiposity (53).

In contrast, in a cohort of healthy Danish girls, a high protein intake was associated with a decrease in body fat and an increase in fat-free mass, depending on the available amounts and combinations of arginine and lysine (49). In another Danish cohort study (54), linear growth in prepubertal girls was influenced by habitual arginine intake, whereas body fat gain was inhibited by the intake of arginine and lysine. Further research should explore the role of specific amino acids on weight gain and body composition.

Recommendation The evidence associating protein intake and obesity in children older than 2 years of age is inconsistent and does not allow firm conclusions and recommendations.

MISCELLANEOUS

Calcium

Dietary calcium intake has been suggested to be negatively associated with the development of obesity. One possible mechanism is reduced intestinal fat absorption. Several studies in both animals and humans have shown that calcium increases the excretion of fat, presumably by formation of insoluble calcium fatty acid soaps or binding of bile acids that impair the formation of micelles (55–57). Another mechanism could be the regulatory influence of intracellular calcium on fat metabolism by modifying lipolysis, fat oxidation, and lipogenesis (55–58).

Despite the above, findings in children and adolescents are inconsistent. Epidemiological data both support (59–63) and refute (64–66) an association between calcium or dairy product intake and the development of obesity. In a cross-sectional study in healthy premenarcheal girls (67), an inverse association between calcium intake and body fat content appeared to result from avoidance of foods high in calcium by girls who were concerned about their body weight or shape. In the longitudinal part of this study, calcium intake was not associated with changes in body fat content over time (67).

Randomised trials conducted to examine the effects of calcium or dairy product supplementation on bone mineral accretion have not detected differences in weight gain between supplemented and control children (68,69). Studies that supplemented the diet of children with dairy products instead of elemental calcium are difficult to interpret, because energy and protein intakes may have also increased in the supplemented groups, thus obscuring any differential effects on changes in weight or body fat.

Recommendation Available evidence does not allow recommendations on the role of calcium or dairy products in the development of obesity.

Dietary Modulators of Gut Microbiota

Recent evidence, primarily from investigations in animal models, suggests that the gut microbiota affects nutrient acquisition and energy regulation (70). In both animals and humans its composition has been shown to differ in the lean and obese (71,72). Interestingly, the gut bacterial flora of obese mice and humans include fewer Bacteroidetes and correspondingly more Firmicutes than that of their lean counterparts, suggesting that caloric extraction of ingested food may indeed be influenced by the composition of the gut microbiota (73). There are no data on the effect of any dietary factor, including prebiotics and probiotics, on the prevention of obesity by modulating gut microbiota.

Recommendation No dietary modulators of gut microbiota can be recommended for obesity prevention.

Plant Foods: Vegetarian Diets

Plant-based diets are low in energy density and high in complex carbohydrates, fibre, and water, which may increase satiety and resting energy expenditure. Two recent reviews deal with the relation between plant food and childhood obesity (74,75). Newby concluded there was no relation between childhood obesity and fruit and vegetables; insufficient evidence regarding beans, legumes, and soy; and slight protection with grains and breakfast cereals, fibre, and plant-based dietary patterns (74). Most of the studies reviewed were cross-sectional, failed to adequately adjust for potential confounders, and did not consider the influence of reporting errors.

Sabaté and Wien (75) explored the concept of plant-based diets because several studies showed that vegetarians were leaner than their nonvegetarian peers (76,77). In their review, they concluded that animal foods (meats and dairy products/eggs) were associated with an increased risk of overweight, whereas plant foods were either protective (cereals, legumes, and nuts) or showed no association (fruit/vegetables and vegetable protein products).

Inadequate intake of energies, protein, calcium, zinc, iron, vitamin B_{12}, and vitamin D related to plant-based diets may occur on a vegetarian diet because of a poor choice of foods and because of high nutritional requirements related to growth and development. Thus, when implementing such diets, appropriate planning (taking into account recommended macro- and micronutrient intakes) and monitoring (growth, zinc, iron, vitamin B_{12}, and vitamin D) should be undertaken by a health care professional.

Recommendation Plant foods can be used as the main food contributors to a well-balanced diet. When a vegetarian diet is practiced, appropriate planning (taking into account recommended macro- and micronutrient intakes) and monitoring (growth, zinc, iron, vitamin B_{12}, and vitamin D) should be undertaken by a health care professional.

Beverages

The majority of studies classify the following as sugar-added beverages: any sugar-sweetened or artificially sweetened fruit-flavoured drinks, sports (natural or artificial) drinks, and drinks that contain 100% fruit juice; carbonated sodas that include sugar or artificial sweetener, caffeinated or decaffeinated; and sugar-sweetened or artificially sweetened, caffeinated or decaffeinated tea or coffee (78).

Two reviews (79,80) systematically addressed the relation between sugar-added beverages and obesity. The first (79) included cross-sectional, longitudinal, and intervention studies, both in children and in adults, and the second (80) included only longitudinal and randomised controlled trials in children and adolescents. Malik et al (79) concluded that sufficient evidence exists for public health strategies to discourage consumption of sugary drinks. Forshee et al (80) concluded that both quantitative meta-analysis and qualitative review found practically no association between sweetened beverage consumption and BMI. The different conclusions can be explained by different study populations, different methodology, and confounding variables. For example, the randomised controlled trial of James et al (81) showed that the percentage of overweight and obese children increased in the control group by 7.5%, and decreased in the intervention group (reduced sweetened beverage consumption) by 0.2%; however, those differences could not simply be attributed to a decline in

the consumption of high-calorie sodas. Moreover, Ebbeling et al (82) observed that although energy intakes from high-calorie beverages dropped by 82% in the intervention group, the difference in BMI gain was not significant.

Since these 2 reviews have been made available, other longitudinal and intervention studies on this topic have been published. Some support the association between sugar-sweetened beverages consumption and BMI (78,83,84), whereas other studies found no association (85,86). Recently, Muckelbauer et al (87) performed a combined environmental and educational intervention promoting water consumption among children in elementary school in a population from socially deprived areas. The intervention was successful in increasing water consumption and preventing overweight without an effect on juice and soft drink consumption.

Overall, results are not conclusive. It is uncertain whether the critical factor is the sugar, energies, or behaviours related to beverage consumption. In addition, some foods frequently accompany certain sugar-sweetened beverages (88), and drinking these beverages may also lead to higher subsequent energy intakes due to producing lower satiety than energy consumed in solid form (89,90). Sugar-added beverages may also encourage additional energy intake because of their high glycaemic index (91). In addition, the high fructose content of many sweetened beverages has been linked to the obesity epidemic (92,93), although it is uncertain whether fructose itself is the culprit (93,94).

Fruit juice also contains sugar and a similar energy density as many sugar-added beverages, but there is uncertainty on their effects. Although it is difficult to separate juices with or without added sugar using the conventional dietary assessment methods, fruit juice intake was not associated with obesity development in several longitudinal studies (78,85,95–100).

Recommendation A relation between sugar-sweetened beverage consumption and development of obesity in children and adolescents has been reported in some studies, although conclusive evidence is not available. Sugar-sweetened beverages are a significant contributor to energy intake. The Committee therefore considers that plain water should be promoted as the main source of fluids for children.

EATING BEHAVIOUR

Eating Frequency

Observations both in adult and child populations associate a lower number of daily meals with a higher risk of obesity (101,102). Several cross-sectional (103–107) and longitudinal studies (108,109) have addressed this issue in children. Cross-sectional studies showed inconsistent results. In the longitudinal studies, Thompson et al (108) observed that eating occasions between 4.0 and 5.9 times per day were negatively associated with changes in BMI *z* score, after controlling for baseline BMI *z* score. In both black and white girls ages 9 to 10 years, followed up for 10 years, Franko et al (109) found that participants who frequently ate more than 3 meals per day had lower BMI-for-age *z* scores than those eating fewer meals. Black, but not white girls, who frequently ate more than 3 meals per day, were less likely to meet criteria for overweight.

Adolescents or adults who eat more frequently also exercise more and make healthier food choices (110), a possible source of confounding. Increased thermogenesis from consuming more meals could be a potential explanation, linking fat mass and meal frequency. However, there is ongoing controversy regarding this mechanism because studies on thermic effects of food do not point to different degrees of thermogenesis when comparing ''nibbling'' (consuming frequent small meals) and ''gorging'' (consuming infrequent large meals) (111).

Recommendation Given the apparent inverse association between number of daily meals and obesity development, it is appropriate that children older than 2 years of age eat at least 4 meals per day. Whether eating 5 or more meals per day provides an additional contribution to the prevention of overweight/obesity remains to be elucidated.

Skipping Breakfast

Breakfast is usually defined as the meal eaten in the morning and the first meal of the day. Skipping breakfast has been suggested to be a risk factor for obesity (112). One systematic review (113) found that although breakfast eaters consumed more daily calories, they were less likely to be overweight. In a recent systematic review of studies performed in Europe, observational studies have consistently shown that children and adolescents who eat breakfast have a reduced risk of being overweight or obese and have a lower BMI compared with those who skip breakfast (114). Three of 4 longitudinal studies performed in the United States (115–118) also showed a relation between skipping breakfast and BMI gain (115–117).

Children who skip breakfast regularly were found to consume a greater percentage of energy from fat (119) and snacks that are higher in fat (120). Skipping breakfast may be followed by increased appetite later in the day, producing overeating, or may promote choice of foods with higher energy density, leading to greater overall intake (121). Alternatively, because a person consumed a nutrient-dense diet, eating breakfast may boost the person's ability to engage in regular physical activity (121).

Recommendation Children should be encouraged to eat breakfast every day.

Family Dinner

Eating family dinner has been linked to healthy dietary intake patterns (122). Two longitudinal studies assessed the relation between family dinner and obesity development. One observed a positive relation, but only in whites, and the other only in the cross-sectional analysis and not in the longitudinal one.

In adolescents between 12 and 15 years of age from the 1997 survey of the National Longitudinal Survey of Youth, Sen (123) observed that, for whites, higher frequency of eating dinner as a family was associated with reduced odds of being overweight, reduced odds of becoming overweight, and increased odds of ceasing to be overweight by 2000. No such associations were found for blacks and Hispanics. Taveras et al (124) found that young respondents who reported eating dinner with families all or most of the time were less likely to be overweight than counterparts who did so only some or none of the time at the baseline, but there was no statistical relation between family dinners and becoming overweight within 1 year. Conversely, in a 5-year longitudinal study of adolescents, Fulkerson et al (125) did not find any significant association between family dinner and obesity development.

Family meals may therefore have relevance for the prevention and correction of childhood overweight. Regular family meals give parents the scope to provide their children with nutritious and healthy fare, to monitor and limit children's intake of calorically dense and ''junk'' food, and to serve as role models for healthy eating behaviour (126).

Recommendation Regular family meals should be encouraged.

Consumption of Food From Fast-food Restaurants

Characteristic qualities of fast foods include large portion size, high energy density, high content of saturated and trans fats, high glycaemic load, low content of fibre, and palatability (appealing to primordial taste preferences for fats, sugar, and salt), which may cause excessive weight gain (88). Few studies have examined the effects of fast-food consumption on any nutrition or health-related outcome. Three studies on the relation between fast food and obesity in children have been identified.

Taveras et al (127) investigated a large cohort of children ages 9 to 14 years at baseline; BMI was obtained from self-reported height and weight. During a period of 1 year, high consumption of fried food away from home was associated with rising BMI compared with those with low consumption at baseline and 1 year later. In a prospective study of adolescents participating in surveys II and III of the National Longitudinal Study of Adolescent Health (116), more numerous days of fast-food consumption at survey II predicted increased BMI *z* score at survey III. Among healthy girls between the ages of 8 and 12 years at baseline and 11 and 19 years at follow-up, those who ate fast food twice per week or more at baseline had the greatest mean increase in BMI *z* score compared to those who ate fast food once per week or not at all (128). From the reviewed studies it can be concluded that increasing consumption of food from fast-food outlets is associated with excess weight gain.

Recommendation Regular consumption of fast food with large portion sizes and high energy density should be avoided.

MEALS COMPOSITION

Snacking

Snacks can be defined as eating episodes, generally smaller and less structured than meals (129). Snack foods can be energy dense and of little nutritional value. They are readily available and consumed by children and adolescents in a variety of settings. Data from 3 cross-sectional studies showed that more frequent snacking intake was associated with a smaller risk of overweight or obesity in children (107,130,131). However, another cross-sectional study in schoolchildren from Colombia showed that the prevalence of overweight was positively associated with snack food intake. In that case, snack food consisted of high-energy sweets and beverages (132).

Three longitudinal studies analysing the effect of snacking on obesity development suggest that low-nutritional-value snack foods were not an independent determinant of weight gain among children and adolescents (133–135). Overall, the available evidence is too limited to establish a relation between snack foods and obesity in children.

Recommendation Healthy food options should be promoted for snacking.

Food Portion Size

The extent to which excessive food portions contribute to children's energy intake and body weight has not been studied extensively. Some studies showed that portion size influence energy intake in children (136,137). In an experimental school lunch situation, the effect of portion size on food intake was influenced by age (138). In a similar study model, doubling an age-appropriate portion of an entrée increased entrée and total energy intakes at lunch by 25% and 15%, respectively; changes were attributable to increases in the average size of the children's bites of the entrée without compensatory decreases in the intake of other foods served at the meal (139). In addition, 1 study showed that meal portion sizes were associated with BMI percentile in boys 6 to 11 years old and in children 12 to 19 years old (140) and another study showed that portion size and energy intake were positively associated with body weight (141).

Recommendation Food portion sizes should be appropriate for age and body size.

STATEMENTS AND RECOMMENDATIONS

1. The origin of obesity is multifactorial. Dietary interventions should be incorporated into a multidisciplinary strategy for obesity prevention.
2. No single nutrient has been unequivocally associated with the development of overweight and obesity.
3. Methodological limitations in study design and the complex nature of obesity must be taken into account when interpreting the association with some of the reported dietary factors.
4. Energy intake should be individually determined, taking into account energy expenditure and growth.
5. Preferential intake of slowly absorbed carbohydrates, along with limiting the supply of rapidly absorbed carbohydrates and simple sugars, should be promoted.
6. With respect to obesity prevention, no recommendations on fat quantity and quality, protein or amino acid intake, or calcium and dairy product intake can be made.
7. No dietary modulators of gut microbiota can be recommended for obesity prevention.
8. Plant foods can be used as the main food contributors to a well-balanced diet. When a vegetarian diet is practiced, appropriate planning (taking into account recommended macro- and micronutrient intakes) and monitoring (growth and potentially zinc, iron, vitamin B_{12}, and vitamin D status) should be executed by a health care professional.
9. Sugar-sweetened beverages are a significant contributor to energy intake. Plain water should be promoted as the main source of fluids for children.
10. Children should eat at least 4 meals, including breakfast, every day. Regular family meals should be encouraged.
11. Fast food with large portion sizes and high energy density should be avoided.
12. Healthy food options should be promoted for snacking.
13. Food portion sizes should be appropriate for age and body size.
14. Nutrition and lifestyle education aimed at the prevention of obesity should be included in the routine care of children by general paediatricians and other health professionals.

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