

Ana Rita Freixo Pereira

Dietary interventions to prevent childhood obesity: a literature review

Ciências da Nutrição

Faculdade de Ciências da Saúde

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Ana Rita Freixo Pereira

Trabalho apresentado à Universidade Fernando Pessoa como parte dos requisitos para obtenção do grau de licenciado em Ciências da Nutrição.

Orientadora:
Professora Doutora Andreia Oliveira

Dedicatória

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List of Abbreviations

BMI – Body Mass Index

COSI – Childhood Obesity Surveillance Initiative

CDC – Centers for Disease Control and Prevention

IOTF – The International Obesity Task Force

NHANES – National Health and Nutrition Examination Survey

SD – Standard deviation

WHO – World Health Organization

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Resumo

Introdução: A obesidade tem aumentando em todo o mundo, sendo as crianças em particular um motivo de preocupação para a saúde pública. A obesidade é uma doença multifatorial complexa. Acredita-se que o rápido aumento da obesidade infantil ao nível populacional possa ser decorrente de interações genes-ambiente, potencializadas por um ambiente obesogénico cada vez mais permissivo, incorporado num modelo contextual com diferentes níveis de determinantes. Sabe-se que a alimentação e outros hábitos são moldados nas etapas iniciais da vida e mantidos até a idade adulta. Portanto, várias intervenções, incluindo mudanças nos hábitos alimentares, foram feitas com a intenção de prevenir/reduzir a obesidade infantil. Sabe-se que a maioria delas tem falhado no combate à epidemia da obesidade.

Objetivo: Este estudo tem como objetivo rever a literatura existente sobre intervenções alimentares para prevenção da obesidade infantil e avaliar a sua efetividade.

Métodos: Realizou-se uma pesquisa bibliográfica usando o motor de busca *PubMed Central*®. Os termos usados para esta pesquisa foram “(pediatric obesity) OR (childhood obesity) AND (primary prevention) AND diet”. Somente artigos publicados nos últimos 10 anos, escritos em inglês e conduzidos em humanos foram incluídos. Nesta pesquisa, foram considerados 17 estudos. Outros artigos adicionais foram incluídos nesta tese (n=84), resultantes de uma pesquisa em *snowball* ou para contextualizar as intervenções alimentares para a prevenção da obesidade infantil, totalizando 101 referências.

Resultados: A maioria dos estudos incluídos nesta revisão foram intervenções realizadas em contexto escolar, com algumas abordando toda a comunidade e incluindo algumas intervenções no setor alimentar (por exemplo, taxaço de produtos com elevado teor de gordura/açúcar, sistema de rotulagem único) e através dos meios de comunicação de massa (por exemplo, restrições à publicidade para crianças) que direta ou indiretamente poderiam ajudar a combater a obesidade infantil.

A maioria dos programas/intervenções realizados foca-se principalmente em abordagens educacionais baseadas no indivíduo, como sessões de educação nutricional/alimentar, aliadas à promoção de atividade física e estilos de vida para os estudantes, pais e funcionários da escola, e menos em mudanças ambientais que fomentem uma oferta de escolhas mais saudáveis. Apenas alguns ensaios clínicos focaram-se na capacitação e

mudanças de macropolíticas, como a adaptação do ambiente escolar, servindo porções menores e aumentando a disponibilidade e acessibilidade de alimentos saudáveis e água nas escolas, e restringindo o acesso a máquinas de venda automática, por exemplo.

No geral, a maioria dos estudos de intervenção não mostrou efeitos consistentes na alteração do índice de massa corporal das crianças; mostraram apenas pequenas reduções de peso, clinicamente irrelevantes ou nenhum efeito. Pouco se sabe sobre a sustentabilidade das intervenções ao longo do tempo. No entanto, outros resultados positivos, como a mudança de comportamento alimentar ou melhoria do desempenho de atividade física, foram descritos.

Conclusões: A maioria das intervenções alimentares para combater a obesidade infantil foca-se principalmente em abordagens educacionais baseadas no indivíduo e menos em mudanças ambientais para oferecer escolhas comportamentais mais saudáveis. A maioria não conseguiu reduzir a obesidade infantil.

A criação de ambientes que apoiem comportamentos saudáveis parece ser a melhor abordagem para mitigar o desafio que é a obesidade. Intervenções multidimensionais complexas, focadas nas mudanças ambientais e no fortalecimento de indivíduos e comunidades, incluindo a família, bem como mudanças de macropolíticas, terão o potencial de combater a obesidade infantil sem aumentar as desigualdades socioeconómicas.

Palavras-chave: obesidade infantil, crianças, intervenções alimentares, alimentação, prevenção

Abstract

Background: Obesity has dramatically increased all over the world and children, in particular, are a cause of public health concern. Obesity is a complex, multifactorial disease. The fast increase of childhood obesity at the population level is believed to be due to gene-environment interactions, enhanced by an increasingly permissive obesogenic environment, embedded in a contextual model with different levels of determinants. It is well known that food and other habits are shaped at the earlier stages of life and maintained through adulthood. Therefore, various interventions, including dietary changes, have been made with the intent of preventing/reducing childhood obesity. Most of them are known to have failed in tackling the obesity epidemic.

Purpose: This study aims to review the existing literature on dietary interventions for the prevention of childhood obesity and to assess their effectiveness.

Methods: A literature search was conducted by using the PubMed Central®. The mesh terms used for this search were “(pediatric obesity) OR (childhood obesity) AND (primary prevention) AND diet”. Only articles published in the last 10 years, written in English and conducted in humans were included. From this search, 17 studies were retrieved. Additional papers (n=84) were included in this thesis from a snowball process or searched to put into context the dietary interventions for the prevention of childhood obesity, totaling 101 references.

Results: The majority of studies included in this review were school-based interventions, with some addressing the whole community, and including some interventions in the food sector (e.g. taxation of high fat/sugar food products, front-of-pack labelling) and through mass media (e.g. restrictions on advertising for children) that directly or indirectly could help to manage childhood obesity.

Most of the programs/interventions conducted focus mainly on person-based educational approaches, such as nutrition/diet education sessions, allied to the promotion of physical activity and lifestyles to students, parents and school staff, and less on environmental changes to offer healthier choices. Only some trials have focused on capacity building and macro-policy changes, such as adaptation of the built environment of the school,

serving smaller portion sizes and increasing the availability and accessibility of healthy foods and water in schools, and restricting access to vending machines, for example.

Overall, most of the intervention studies showed no consistent effects on changing the body mass index of children; they have only reported small weight reductions, clinically irrelevant or no effects at all. Little is known on the sustainability of interventions over time. However, other positive results, such as the change of dietary behaviors or physical activity performance have been described.

Conclusions: Most dietary interventions to tackle childhood obesity focus mainly on person-based educational approaches and less on environmental changes to offer healthier behavioral choices. Most of them failed to reduce childhood obesity.

The creation of environments supportive of healthier behaviors seems to be the best approach to mitigate the challenge that is obesity. Complex and multi-level interventions focused at environmental changes and the strengthening of individuals and communities, including family, as well as macro-policy changes will have the potential to tackle childhood obesity without increasing socioeconomic inequalities.

Keywords: pediatric obesity, children, dietary interventions, diet, prevention

1. Introduction

In the recent past, there was a shift from prevailing infectious diseases to a high prevalence of chronic and degenerative diseases associated with lifestyle choices (1). Obesity is one of the entities that has dramatically increased all over the world, and children in particular are a cause of public health concern (2).

The prevalence of overweight and obesity in children and adolescents aged 2-19 years in developed countries has risen greatly in the last four decades, with a prevalence from 16.9% for boys and 16.2% for girls in 1980, to 23.8% for boys and 22.6% for girls in 2013 (2). This alarming rise is also evident in developing countries, with an increase of childhood overweight and obesity from 8.1% for boys and 8.4% for girls in 1980, to 12.9% for boys and 13.4% for girls in 2013 (2). The Childhood Obesity Surveillance Initiative (COSI) has however described a possible decrease of the prevalence of childhood obesity in some European countries, such as Portugal, describing that the prevalence of obesity has decreased ~4% in Portuguese children aged 6-8 years old from 2008 to 2016 (3), highlighting the possible benefit effect of several activities/programs developed in the country to prevent childhood obesity.

Obesity is a complex, multifactorial disease. Even though genetics may be an important etiological factor for obesity development, it does not explain its huge and so fast increase at the population level (4,5). It is believed that this obesity epidemic may be due to gene-environment interactions (5), enhanced by an increasingly permissive obesogenic environment (1), embedded in a contextual model with different levels of determinants. There are micro-environmental settings, like schools, workplaces, homes and neighborhoods, and these are influenced by macro-environmental sectors, like the health systems and the food industry (6). Now, more than ever, individuals are embedded in a more permissive environment in concern to eating habits and are more likely to adopt sedentary behaviors. It has been recognized many years ago in the Ottawa Charter that it is very important to promote supportive environments (7). In the case of children, the family and the school are included in a wider proximal context (6).

It is well known that food and other habits are shaped at the earlier stages of life and maintained through adulthood (8). With the current increasing rates of childhood obesity, there has been an increasing number of studies that focus on determinants of obesity in

children and their families, and a number of studies that have studied possible dietary/nutritional interventions to prevent childhood obesity (9). It is known that interventions that are based mostly on educational, behavioral or pharmacological measures are not very effective in preventing and treating obesity (10).

This study aims to review the existing literature on dietary interventions for the prevention of childhood obesity and to assess their effectiveness.

2. Methodology

A literature search was conducted by using the PubMed Central® search engine as it represents the more comprehensive dataset for biomedical literature. The mesh terms used for this search were “(pediatric obesity) OR (childhood obesity) AND (primary prevention) AND "diet”. Due to the large amount of published data, we limited the timeline to have only articles from 10 years ago to 2019. Only articles written in English and conducted in humans were included. From this search, we got 538 articles, from which we excluded 521 of them, including in this study 17. The literature search had three stages, the search for the titles, then the abstracts and finally the full paper was search and retrieved (when deemed of interest). Some articles were discarded because they did not report measures to prevent obesity in children (n= 199) or because these measures were implemented only in adults (n=322).

Additional papers (n=84) were included in this thesis from a snowball process or searched to put into context the dietary interventions for the prevention of childhood obesity, totaling 101 references.

3. Literature Review

3.1.Obesity definition in children

The definition of obesity has gone through various changes over time. Currently, according to the World Health Organization (WHO), it can be described as abnormal or excessive fat accumulation that presents a risk to health (11). A crude population measure

of obesity is the Body Mass Index (BMI), obtained by dividing the weight (in kilograms) by the square of height (in meters).

There is not a consensual cutoff point for defining overweight and obesity in children. The Centers for Disease Control and Prevention (CDC) from the United States classifies overweight as a percentile of BMI-for-age at or above 95 and "at risk of overweight" as a percentile of BMI-for-age between 85 and 95 (12). International Obesity Task Force (IOTF) assumes that the correspondence to an adult BMI of ≥ 25 to < 30 kg/m² is classified as overweight, and the correspondence to an adult BMI of ≥ 30 kg/m² is considered as obesity (13). More recently, the WHO (WHO) has described development charts for children 0 up to 5 years old and 5-19 years old. WHO standards to children considers a child or infant overweight when is between > 2 Standard Deviations (SD) and ≤ 3 SD of the median in weight-for-length or weight-for-height or BMI-for-age. A child is obese when weight-for-length or weight-for-height or BMI-age is > 3 SD of the median (14,15,16).

3.2.Epidemiology of childhood obesity

The prevalence of overweight and obesity has increased substantially over the past four decades. Recent estimates point out an epidemiological transition from underweight to overweight and obesity throughout the world (17). This alarming rise has been observed in all regions of the world, including developing countries, with an increase from 8.1% for boys and 8.4% for girls in 1980, to 12.9% for boys and 13.4% for girls in 2013 (2). There have also been substantial increases in developed countries, among children and adolescents, with 23.8% of boys and 22.6% of girls being either overweight or obese in 2013 (2). Although the prevalence is clearly higher in developed countries at all ages, the differences between sexes are small. Nonetheless, the prevalence of childhood obesity in the United States and in some European countries, such as Portugal has apparently reached a plateau (18), but it continues in high rates.

In Europe, the WHO has been conducting the COSI study that has periodically assessed the prevalence of overweight and obesity among 6-8 years olds at schools (19). COSI main goal is to create a systematic network that collects, analyses, interprets and disseminates descriptive information in children aged 6-8 years old on their nutritional status. This system is important to obtain information about nutritional status and

assessing and monitoring the prevalence of obesity in children, also allowing to identify groups at risk (19). In Portugal this study is called COSI Portugal and provides by excellence the data on prevalence of underweight, overweight and obesity in Portugal in children aged 6-8 years (19). According to this data, a possible decrease of the prevalence of childhood obesity in some European countries, such as Portugal, has been described, suggesting that the prevalence of obesity has decreased ~4% in Portuguese children aged 6-8 years old from 2008 to 2016 (3), highlighting the possible benefit effect of several activities/programs developed in the country to prevent childhood obesity.

In Portugal, according to data from the National Food, Nutrition and Physical Activity Survey 2015-2016, 18% of children (3-9 years old) and 24% of adolescents (11-17 years old) have pre-obesity, and 7.7% of children and 8.7% of adolescents have obesity (20). No significant differences were found between sexes, and although some geographical region disparities, differences of obesity prevalence across regions were not statistically significant (20).

3.2.1. Life periods for obesity development

There are certain periods of life, called critical and sensitive periods, in which obesity can more frequently occur (22,23,24).

The critical periods are periods in which the exposure to certain factors may carry an increased risk for developing irreversible anatomical or functional changes that carry consequences for particular outcomes with long-term effects, and any time frame outside this specific critical period does not bring any additional risk for the development of the disease (23,25,26). One example of a critical period is the fetal life, in which there is an intense development and exposure to specific factors which can result in the irreversible “programming” of the physiological function, important for the etiology of obesity (23,27,28). In general, literature identifies the prenatal period, infancy, childhood and the pubertal timing during adolescence as critical periods for the development of obesity.

The sensitive periods are periods in which the effect of some exposures is stronger when comparing with the effects of that same exposure outside of this specific period (25,26). An example of a sensitive period is adolescence, because there are a series of developmental

stages happening at different time periods, and there may not exist any specific critical period.

3.3. Conceptual frameworks to identify determinants of obesity

It is consensual in the research community that the best approach to understand obesity development is a multidimensional approach that focus at various levels. To theorize these multilevel methods to obesity determinants it was created the Ecological Systems Theory, which considers the “ecological niche” in which the individuals are placed (6).

The Ottawa Charter recognized many years ago that it is really important to promote supportive environments (7). And from then on, more sophisticated environmental models have been developed to consider the interrelationship between a diversity of factors using more comprehensive models (25,26), and to deal with some of the key determinant factors of obesity, which include the diet and physical activity.

According to these models, there are micro-environmental settings, like schools, workplaces, homes and neighborhoods, and these are influenced by macro-environmental sectors, like the health systems and the food industry. Focusing on this settings seems to be a promising approach, as the interventions that are based mostly on educational, behavioral or pharmacological measures, do not seem to be very effective in preventing and treating obesity (10).

A model for health promotion should be focused not only in the individual, but also in the social environmental factors that may promote health through interventions. This socioecological approach allows us to identify the different levels of health determinants: individual (e.g. gender), family (e.g. parenting style), organizational (e.g. school policies), community/neighborhood (e.g. food retails), and public policy (e.g. taxation), and their interaction (30).

There is also another framework proposed for determinants of physical activity and eating behaviors, which defines three types of influences conceptualized hierarchically: behavior settings (like psychobiological, cultural, social and lifestyles factors), proximal influence points that control behavior settings (like familial and community influences), and distal influence points (like political and policy determinants), that have indirect effects on the behavior settings (31).

It is well known that habits are shaped at the earlier stages of life and maintained through adulthood (8). With the current increasing rates of childhood obesity, there has been an increasing number of studies that focus on determinants of obesity in children and their families (9).

3.3.1 Early-life determinants of obesity

A review of systematic reviews summarized the main factors for childhood obesity from conception up to 5 years of age, which were: gestational diabetes, maternal smoking, rapid infant growth and obesity in infancy, short-sleep duration, less than 30 minutes of daily physical activity, and consumption of sugar-sweetened beverages (32). A possible protective factor described was breastfeeding (32).

There is evidence that the intrauterine programming may have an important effect on child's body fat at pre-school age through maternal gestational weight gain, diabetes and smoking (33). Another important factor is that the parents of premature or children with low birth weight may provide higher intake of food in those children which will reflect later in their eating habits (34), and possible weight status.

Children naturally prefer sweet foods, so the exposure to healthier foods both *in utero* and through breastfeeding lead to a better acceptance of this foods later in life (35).

To a better acceptance of all foods, and to obtain a varied and balanced diet for the child, there are some important practices, such as repeated exposure, introduction of a variety of foods, and the right timing for weaning (8).

3.3.2. Social determinants of obesity

There are many social determinants in the context of obesity, such as socioeconomic status, education, health literacy, residential conditions, access to health care, social support or working conditions (36). Children from higher socioeconomic status families are more likely to have better quality of residential space that accommodates their needs, therefore have a lower probability of being exposed to crowding and unhealthy foods (37). The social determinants of health are responsible for health inequities inside and between countries. There were reported huge socioeconomic inequalities in terms of obesity, particularly in Europe. It has been shown that obese people that are from lower

socioeconomic groups are getting heavier at a faster rate, particularly the ones that also have a low education level. A huge percentage of the premature mortality and loss of healthy years present in lower socioeconomic groups is due to obesity-related diseases (38). According to the WHO, the prevalence of obesity is higher among the female sex in the European Region (36). This is because women have a higher propensity to gain fat (39).

3.3.3. Family's environment as determinant of obesity

The family environment includes parenting styles, child-feeding practices or the parent's diet that influences the child's weight through its effect on the child's diet (40).

Parenting styles and parenting practices in child-feeding

The parenting styles consist in two dimensions: demandingness (number/types of control and expectations parents place on the child) and responsiveness (extent to which parents demonstrate consideration for child's emotional needs). From these two dimensions, four parenting styles can be considered: Authoritative, Authoritarian, Indulgent, and Neglectful (40). In 2015 a narrative review (41) showed that authoritative parents were found to have healthier kids in terms of weight-related outcomes. However, in 2014 (42), a meta-analysis showed that a positive parent-child relationship and higher levels of responsiveness were associated with lower weight but that most effect sizes were small. This concludes that parenting styles should not be the main targets of preventing and treating obesity.

Another important factor that could influence the child's eating habits and weight status is the parental-child feeding practices (41), such as the use of food as a reward. This practice may lead to the child eating without having hunger, which may result in an excessive calorie intake, ultimately leading to obesity. Therefore the foods should be provided only when the child's expresses hunger and not as a reward (8). Depending on the context, the food parenting practices can have a bigger or smaller influence in the children's eating practices and weight (41). In 2015 a narrative review showed that a stronger parental control results in either a low adiposity in the long-term or minimal impact on children's weight (41). The literature about parental control showed conflicting

results which may be due to different factors like its complex nature, a lack of distinction between practices and styles, and the possibility that the parenting practices depend on the parenting style (36,38).

Parental diet and parental characteristics

The parental characteristics (e.g., income, education, weight), the food environment at home, parental nurturing and the parental dietary intake can also influence greatly the children's eating habits, and consequently their weight. It is supported by evidence that the home food environment and shared family meals are associated with childhood obesity, by affecting children's behavior (44).

There is strong evidence regarding the relation between food availability and eating habits; some studies have shown that children that have a bigger availability of healthy food are more likely to have a healthier diet (40).

Research also shows that there is a strong association between parental and child obesity in numerous countries (45). This associating can be simply due to living in the same environment, but can also be genetics-related (46).

Other psychosocial factors within the family environment

Children's dietary habits (and consequently their weight status) are not only affected by the parents, but also caregivers, peers and siblings (6). Usually, on the daily routine, children are fed by someone other than parents, like their grandparents, other relatives or caregivers in childcare (47).

There is not much evidence regarding family composition and peer's diet associating with the children's dietary intake, but siblings are reported to influence each other's food intake, more commonly in a negative way, with a positive association reported between the sibling's intake and obesity among adolescents (47).

It has also been shown that there is an association between psychological stress and childhood obesity (44). Some of the underline factors are the negative life events, maltreatment, impaired family communication and parental stress. Additionally, there is evidence that there is a positive association between depression and obesity, and between a worse mother's emotional and mental well-being and childhood obesity (44).

3.3.4. Dietary influences on obesity

The effects of dietary choices on weight status have a complex nature and methodological challenges for their assessment, which may explain the lack of supportive evidence.

Foods

Evidence supports a relationship between the consumption of certain foods and the development of obesity, although overall there is a lack of consistent associations.

The most robust evidence from relationships between diet and childhood obesity comes probably from the consumption of sugar-sweetened beverages. There is a large amount of evidence that shows a relationship between the consumption of sugar-sweetened beverages and weight gain in children (48). Thus, policies to reduce the consumption of these beverages seem to be beneficial as a public health strategy.

It has also been suggested that the consumption of fruits and vegetables could have a protective effect against obesity due to their low-energy density and high content in fiber, vitamins and phytochemicals, their satiating effects and because they could potentially be a substitute of energy-denser foods from diet (49). But recent studies have shown that because they can contain large amounts of simple sugars (glucose, fructose, sucrose), they can be responsible, at some extent, for some weight gain (50).

Prospective epidemiological studies show that a diet rich in whole grains is associated with a lower BMI (51). Nonetheless, according to some clinical trials there is no evidence that a diet rich in whole grains and low in calories is more effective in reducing body weight than a rich in refined cereals one (52).

Another relationship that needs more evidence is the consumption of dairy products, which have been negatively associated with obesity (53), and the high consumption of red meat, which has been positively associated with the risk of developing obesity (54).

Caloric intake

In theory, it is assumed that the excessive gain of body fat is mainly due to a high caloric intake, to which there is not enough scientific evidence. The National Health and Nutrition Examination Survey (NHANES) discovered only slight increases in calories intake among US children from the 1970s to 1988–1994, even though there has been

observed a huge rise in childhood obesity in the US (55). The Bogalusa study, which followed the diet of 10 year old children from Bogalusa from 1973-1988, found that their caloric intake did not change in this period of time (56).

Nutrients

There is not a specific nutrient associated with the development of childhood obesity, and there is also no particular macronutrients recommendations to avoid its development (57).

Although there is no conclusive results about the effects of fat, but as it contains twice as much energy as carbohydrates and protein, a lot of studies have been made concerning this topic (58). Since diets high in fat have high density and palatability, the individuals are more likely to have a higher voluntary energy intake (58). Despite this, some clinical trials showed no weight reductions when comparing low-fat diets to isocaloric low-carbohydrate ones followed by children and adolescents (58). Some randomized controlled trials compared low-glycemic index or load diets with higher glycemic index or load diets, concluding that there was a higher weight lost and improvement in lipid profiles in those who followed a low-glycemic index or load. However, the long term effects of a diet with low in glycemic index should be studied (59). The prospective study Generation XXI studied the effects of dietary glycemic load on adiposity in children (60). The obtained results were that boys with high-glycemic load diets at 4 years of age had more adiposity at 7 years of age (60). Another discovery made was that the glycemic load seemed to interact with the protein intake, leading to an even bigger adiposity increase. There was observed a positive association between the consumption of protein at preschool age with later BMI, in both boys and girls. A positive association was also found in boys between the consumption of protein at preschool age and the fat mass index (60).

Dietary patterns

The Mediterranean diet has been widely negatively associated with the development of obesity, but not particularly in children. These effects are probably due to its high consumption of plant-based foods rich in fiber, its low-energy density and low-glycemic load (55,56). Therefore, some studies suggest diets to prevent obesity which are based on the Mediterranean diet. These diets consist in high fiber-rich cereals, fruit, vegetables,

fish, olive oil and nuts; fat-reduced diets, low in meat, processed meat foods and trans-fatty acids, and restricted in energy-containing drinks. A vegetarian diet was also associated with a lower BMI and a lower prevalence of obesity both in children and adults (63).

3.3.5. Physical inactivity as determinant of obesity

One of the main factors for the increase of obesity in all ages might be the growing decline in physical activity (64). It has been proven in multiple studies that there is a relationship between the increase of hours spent watching TV and playing video games and the growth of obesity (61,62). Watching television for more than 120 minutes per day has been positively associated with childhood obesity, which can be due to an increased sedentary lifestyle and consumption of unhealthy food advertised through TV advertisements (67). Furthermore, there has been an increase in the children driven to school and a decrease in participation in physical activities at schools, especially among adolescent girls (65), being this factors associated with an increased obesity prevalence. The only sedentary activity that seems to be negatively associated with obesity is sleep (68).

A systematic review of randomized controlled trials concluded that exercise combined with dietary changes is an effective intervention to weight loss (69). Nonetheless, the relationship between physical activity and obesity is still under research. It was suggested in some epidemiological studies that an increase in physical activity can be beneficial to health in general, but once the physical activity increases the effects can be softened (70).

3.4. Interventions to tackle childhood obesity

To prevent obesity in children there is a need to take actions at a multidimensional level, including several levels of intervention, such as individual, familial, institutional, and environmental. To the moment, these type of multilevel interventions seem to be the most promising ones to actually prevent/manage obesity. In particular children are very influenced by social and environmental conditions, so at these ages, community-based interventions, changing the supportive environment, seem to play an especially important role (71).

Table 1 provides a descriptive summary of the dietary interventions to tackle childhood obesity, described in detail below.

3.4.1. School-based interventions

The Ballabeina study is a cluster randomized controlled single blinded trial that took place in some preschools in Switzerland, designed to study the effect of a multidimensional lifestyle intervention on aerobic fitness and adiposity, mainly in migrant preschoolers with the duration of over one school year (72). The study included 652 preschool children with a mean age of 5.1 years. The interventions of this study included a physical activity program, lessons on nutrition, media use and sleep, and adaptation of the built environment of the preschool. The dietary intervention included weekly nutrition lessons given by a dietician, where the students would learn about balanced nutrition and healthy nutritional behaviors in a didactic way. These lessons were centered on five messages: "drink water", "eat fruit and vegetables", "eat regularly", "make clever choices", "turn your screen off when you eat" that were developed in collaboration with the Swiss Society for Nutrition. These messages were also described on funny cards that the children could take home with a task to implement the message at home. After 4 months of intervention, the results showed no differences between groups regarding the BMI of the children. However, it was reported an increase in aerobic fitness by the end of the intervention and children in the intervention group also showed beneficial effects in the percentage of body fat (-1,1%), and their motor agility, when comparing with the children in the control group. It was also possible to observe benefits in reported physical activity, media use (less screen time in boys) and eating habits, such as an increase in fruit and vegetables consumption in the intervention group (72).

In the Netherlands it was implemented a school-based trial which included students from the ages of 12-14 years old (n=1108), within a multidimensional health promotion intervention. This trial included an educational component, with classes in biology and physical education, and computer-based information program; and an environmental component, with propositions such as serving smaller portion sizes in the canteen and healthier options, or restricting the access to vending machines. There were also posters affixed to create more awareness about which foods were healthy and which were not. With a twelve-month follow-up, it was observed in the control group a reduction in the skinfold thickness, lower consumption of sugar-containing beverages, and less screen time (but only in boys) (73,74).

In a school-based obesity-prevention trial in Chile it was evaluated the effect of weekly physical activity classes and classes on healthy nutrition for parents and students from the 1st to the 8th grade; 2141 schools were in the intervention group and 945 in the control group (75). There were also made some environmental changes in this intervention, among them, school kiosks were instructed to offer healthier choices to students and shown how they could still remain lucrative. The results showed a reduction of BMI z-scores in boys and a better physical fitness in both genders. On the other hand, the modifications in the kiosks food availability did not seem to change the student's food choices (75).

The school-based Healthier Options for Public School children (HOPS) is a randomized trial implemented over 2 school years (2004–2005 and 2005–2006) that included 6 elementary schools (4588 children aged 6 to 13 years; 48% Hispanic) in Osceola, Florida. The interventions implemented were modifications in the school menu, school gardens, and physical activity (76). Complementarily, there were healthy nutrition and physical activity lessons for the students and parents through monthly newsletters. After 2 years, it was possible to observe a higher percentage of students who maintained a normal weight (under the 85th percentile of BMI-for-age) in the intervention group (52.1%) when comparing with the control group (40.7%). Students in the intervention group had also an improved academic performance in comparison with the control group (76).

The “Shape up Somerville” (SUS) is a non-randomized controlled trial conducted over two school years (September 2003–June 2005) in 1178 children in grades 1–3 (average of 8 years) attending public school in three different communities from Somerville, Massachusetts, United States (77). This intervention included more physical activity opportunities around the school, like information on safe routes to school and walking to the school bus; modifications inside the school space, like new equipment for physical activities; and dietary intervention, such as:

- A fruit or vegetable was highlighted each month in the schools and taste tests were done during lunch periods. The children would then vote on whether or not they would like to have the featured fruits and vegetables on the monthly school menu;
- Colorful educational posters were displayed around school cafeterias with nutrient and health information;

- Food service staff received training on nutrition education, knife skills, and food safety;
- New vegetarian recipes were developed and salads were made fresh each day;
- Fresh fruit was made available every day for breakfast and lunch.

Additionally, there was an approving of restaurants according to SUS guidelines which were: offer low fat dairy products; offer some dishes in a smaller portion size; offer fruits and vegetables as side dishes; and have visible signs highlighting healthier options.

After 1 year, the results showed that the BMI z-scores in the intervention group were 0.06 lower than the ones in the control group. There was a decrease in overweight and obesity and an increase in remission in both sexes in the intervention group (77), but comparison groups were not randomly assigned.

A randomized cluster controlled trial was performed in Mexico on 532 school-aged children from the 2nd and 3rd grades (280 children in the intervention group and 252 in the control group) (78). The aim of this study was to make these children and their parents to reduce their sedentary behaviors, the consumption of soft drinks, and high-fat and salt containing snack foods, and increase their consumption of fruits and vegetables. The interventions consisted of sessions for discussing healthy lifestyles dedicated to the school board and the teachers, carried by nutritionists and physical activity professionals. Some of these sessions were used to discuss methods to improve the eating habits of the students in the school and their physical activity practices during and after school, as well as discussing ways to improve the physical activity installations. There were also interactive lessons provided by nutrition graduated students to the children with the purpose of increasing their fruit and vegetables intake, as well as their physical activity practice, and to reduce their intake of soda and high fat and salt containing snacks, while simultaneously lowering their TV watching time. Regarding the parents, there were also nutrition sessions carried by nutrition professionals, with the intent of educating them about healthy eating. The results showed that by the six month of this study there was a greater decrease in BMI in the intervention group than in the control group (difference of -0,82 kg/m² in children BMI), although it was not sustained after 18 and 24 months (78).

A Multicomponent School Nutrition Policy Initiative on the prevention of overweight and obesity among children was conducted in 1349 students in grades 4 through 6 from 10

schools in a US city (79). This initiative included the following interventions: school self-assessment, in which the schools suggested strategies like limiting the use of food as reward/punishment, promoting active recess, and serving breakfasts in the classrooms to assure the students eat a healthy breakfast; training in nutrition education for the school staff; nutrition education classes for the children; nutrition policies in the intervention schools, like the foods that were sold and served were changed according to the Dietary Guidelines for Americans to meet the nutritional standards; social marketing, like giving raffle tickets to students who purchased or brought from home healthy snacks and beverages; and parent outreach through nutrition educators in home and school association meetings, report card nights, parent education meetings, and weekly nutrition workshops (79). The results of this intervention were a 50% reduction in incidence of overweight. There were significantly less children in the intervention schools (7.5%) than in the control schools (14.9%) who became overweight after 2 years. There were no differences observed in the incidence or prevalence of obesity, nor in the remission of overweight or obesity after 2 years of follow-up (79).

Donnelly et al. (80) did a 2-year trial in students from grades 3 to 5 in two school districts in rural Nebraska with the objective of attenuating obesity and improving physical and metabolic fitness. The interventions consisted of nutrition education, modified school lunches, and increased physical activity. The meals were planned with the kitchen staff according to the Lunchpower! Program. This program consists of reduced energy, fat, and sodium lunches, consistent with the objectives of the Healthy People 2000 (81). According to this, the fat content is restricted to 30% of the total energy, the sodium is limited to 1000 mg, the cholesterol to 100 mg, and the dietary fiber is increased to 8 to 10 g.

There were also nutrition classes given by the existing teacher after being trained to do so correctly. These classes included basic nutrition, the relationship between diet and general health, nutrition for proper growth and development, healthy food choices, snack alternatives, reducing fat in the diet, and food safety.

After two years of intervention, the control school showed significantly greater total energy (9%) and total fat (25%). The control school also showed considerably greater values for sodium and smaller for fiber. After the first year of intervention there were no significant differences between the control and the intervention school regarding nutrition

knowledge. However, after two years of intervention the intervention school reduced by 45% their wrong answers about nutrition knowledge.

Concerning the physical activity, the control school practiced significantly more outside of school compared to the intervention school. After 2 years of the intervention neither the control or intervention school showed significant increases in aerobic capacity. Both schools showed no significant changes in the percentage of body fat, but a significant increase in the BMI (80).

3.4.2. Community-based interventions

The MOVE/me Muevo was a randomized community trial implemented in 30 recreation centers in the San Diego County in a total of 541 families with children between the ages of 5 and 8 years old with the purpose of preventing and controlling childhood obesity (82). This program consisted of activities at the recreation centers and participant's houses, as well as phone calls from health coaches and emailing tip sheets. The intervention families had "Family Health Coaches" who addressed the following nutrition behaviors: increasing the consumption of vegetables and fruits through modifications in meal and snack purchase and preparation; decreasing the consumption of sugar-sweetened beverages through changes in food purchase and setting limits; increasing healthy food portions by modifying the food consumption behaviors; reducing eating out and when eating out, choosing healthier options; increasing the availability and accessibility of healthy foods and beverages at home; reducing the screen time and avoiding eating in front of the television; and increasing the number of meals eaten as a family. After 2 years, there was no significant differences between the control and the intervention group concerning BMI or waist circumference (82). Some changes were observed in the dietary domain, namely a reduction in fat and sugary beverages, which means that is it easier for the participants to adopt healthier behaviors in this field, comparing with more complex and multidimensional attitudes of physical activity.

The "Romp & Chomp" is a community-based trial carried out in Australia in children aged 0–5 y (n =12,000) and their families (83). There were changes regarding the provision of water in childcare centers, childcare policies regarding healthy eating and physical activity; and skills in physical activity and nutrition were taught to the childcare professionals. Amongst the nutrition interventions were: a collaboration with Dental

Health Services Victoria, which provided some resources (lunch boxes, drink bottles, and social marketing material for kindergarten children); staff trained to reinforce nutrition messages and healthy eating choices for children aged 5 years; support given to the kindergartens from dental health professionals to engage with parents on the topic of healthy eating and to provide support for staff to adopt and implement health and well-being/nutrition policies; access to a dietitian and other allied health professionals through e-mails, phone calls and site visits; production and distribution of promotional materials (balloons, stickers, posters, postcards). After 3 years of intervention, the 3.5 years old subsample showed considerably lower mean weight, BMI, and z-score BMI and the 2 and 3.5 years old showed considerably lower prevalence of overweight and obesity in when compared with the baseline values. The intervention group also showed considerably lower intake of packaged snacks and fruit juice (83).

The Aventuras Para Niños Study is a community-based intervention to promote healthy eating and physical activity and prevent excess weight gain in Latino children (84). It was performed in thirteen elementary schools, with a randomization to assign them to either a Family-only intervention, a Community-only, or a Family+Community intervention. In the Family-only intervention professionals would either call the family's or make home visits as a way of discussing ways to pass through the difficulties of maintaining a healthy diet and being physically active, by showing them how to prepare healthy meals at home, as well as presenting them with the benefits of encouraging their children to eat healthy and practice physical activity. The Community-only intervention included improving the school's playgrounds, implementing salad bars, as well as community parks, displaying water bottles in the classrooms for the students. It also included the implementation of better physical education equipment and healthy menus for the children, all of this combined with spreading media messages through posters, news and point-of-choice messages in grocery stores, with healthy messages. The Family+Community included all of the interventions above. The results showed no noteworthy main effects for the family or community interventions. Therefore, it is possible that there were not any real effects for the family or community interventions in the BMI z-scores of the children compared with either of those circumstances alone. Despite the lack of significant effects on the children's BMI z-score, there were multiple obesity-related behaviors in this children that were changed by the family intervention, like an increased consumption of fruits and vegetables (84).

The EPODE (Ensemble Prevenons l'Obésité Des Enfants/Together Let's Prevent Childhood Obesity) aims to reduce childhood obesity through a societal process in which local environments, childhood settings and family norms become more supportive and facilitate the adoption of healthy lifestyles in children – enjoying healthy eating, active play and recreation (85). It was launched in 2004 in 10 French pilot communities, targeting children aged 0–12 years, and their families, as well as a wide variety of local stakeholders who can initiate micro-changes in children and their families through local initiatives fostering better and balanced eating habits and greater physical activity in everyday life. Other programs, inspired by EPODE methodology, have been launched recently such as the JOGG program in the Netherlands or the Healthy Weight Communities in Scotland.

The Pacific Obesity Prevention in Communities (OPIC) project was carried out in four countries – Australia, Fiji, New Zealand and Tonga over a period of 30 months, between 2004 and 2009 (86). Adolescents from eight ethnic and cultural groups were selected to participate in a complex community-based intervention which included 18 000 secondary-school children (aged 12–18 years), 300 stakeholders and partner organizations, 60 multi-professional research staff and 27 higher degree research students. The interventions varied somewhat across sites according to local conditions, but similarities across all sites include targeting reductions in the consumption of high sugar content drinks and energy-dense snacks and increasing structured and unstructured physical activity. The authors state that the project can produce positive effects in diet and physical activity, but effects on childhood obesity are not clearly described (87).

3.4.3. Interventions through mass media

Some interventions to tackle childhood obesity through mass media have been based on restrictions on advertising for children. It has been shown that restricting the number of hours spent watching television (TV) can be an effective approach to reduce the prevalence of childhood obesity, and reducing the meals in front a TV has been shown to be as important as increasing physical activities (88). Energy-dense foods and drinks and fast-food companies often target children in their advertisements, since they are very easily influenced at young ages, namely through TV commercials. Thus, reducing the time spent in front of the TV might be a useful strategy to try to reduce childhood obesity

prevalence. Sweden has banned TV commercials to children under the age 12, and TV advertising to children. Norway, Denmark, Austria, Ireland, Australia, and Greece have also made some restrictions on commercials for children (89).

On March 15, 2019, a law to restrict advertising to children in Portugal was approved, which came into force 60 days after its publication. This determines that advertising for foodstuffs and beverages of high energy value, salt content, sugar, and saturated fatty acids will be banned in pre-school, basic and secondary schools, in playgrounds or in the 100 meters around these locations (90). Also, advertisements of these food products on TV and radio programs broadcast in the 30 minutes before and after children's programs or with a minimum of 25% audience of children under 16 will be banned. Thus also applies to advertising broadcast on movie theaters in films for children under 16 and, on the Internet, on websites, pages or social networks, with content for this age group. The use of mascots, drawings, figures and personalities related to the child and youth audience in this type of products will also be prohibited. Brands should also refrain from encouraging excessive consumption, creating a feeling of urgency or need to consume the advertised product or from transmitting the idea of benefit in their exclusive or exaggerated consumption (90).

3.4.5. Food Sector interventions

A primordial prevention intervention through the food sector that is currently being taken in several countries, like some parts of the USA and Canada (91), trying to reduce the intake of unhealthy foods, and in the long-term to reduce their health effects such as obesity, is their taxation. Some examples are high-volume foods with low nutritional value, such as soft drinks, confectionery, and snack foods. Portugal also adopted the taxation of sugar-sweetened beverages as an intervention to reduce its high consumption in the country. There was a decrease of 6.58 million liters per year using taxation, which translates into a decrease in consumption of 21% compared to the baseline consumption data of the National Dietary Survey (IAN-AF 2015–2016) (92). The number of cases of obesity prevented by taxation of sugar-sweetened beverages was studied, concluding that there was a higher impact in adolescents (0.012%), preventing 0.76 cases of obesity yearly, followed by an impact of 0.062% in adults aged 18 to <65 years, and the children showed an impact of 0.049%. The older adults aged >65 where the ones where the impact was less noticeable (0.023%). This data shows that Portugal achieved its goal, decreasing

sales of sugar-sweetened beverages (93). As mentioned previously (chapter 5.4), there is a consistent association between the intake of these beverages and childhood obesity (48).

Another measure being currently taken is the addition of logos or some type of labeling that alerts the consumers to the products that are healthier, providing this way an easier healthy food choice. Although it is not directly focused on childhood obesity, it can have indirect effects on the disease. An example of this intervention is the “Pick the Trick” program, which is taken in Australia and New Zealand, providing foods with symbols for the consumers that make it easier to identify the healthier choices (94). In Europe, the WHO European Food and Nutrition Action Plan 2015–2020 identifies the introduction of interpretative, consumer-friendly labelling on the front of packages as a priority policy issue (95). Although the majority of countries in the region (n=15) have some form of front-of-pack labelling, fewer countries have interpretive systems which provide judgements about the relative healthfulness of foods. Among other future policies, there is the intention of application of a single front-of-pack labelling system in all countries. A WHO report summarizes the existing evidence on development processes and effectiveness of front-of-pack food labelling policies in the WHO European Region (96).

The portion sizes have also been getting increasingly larger over the past 4 decades in most higher income countries (94,95). Despite this increase in portion sizes, few countries report measures to reduce them. Most measures are focused on information to consumers rather than changes in the food and drink environment (99).

4. Discussion/Conclusions

As obesity is a complex multifactorial disease, a need to take actions at multidimensional levels, including the individual, familial, institutional and environmental levels, have been explored in the literature.

The majority of the studies included in this review were school-based interventions, with some addressing the whole community, and including some distal interventions through the food sector and through mass media that by changing food behaviors can have an indirect effect on childhood obesity.

Children are very influenced by social and environmental conditions, so at these ages, the modification of the environment is expected to play an important role. However, most of

the programs/interventions conducted focus mainly on person-based educational approaches, such as nutrition/diet education sessions, allied to the promotion of physical activity and lifestyles to students, parents and school staff, and less on environmental changes to offer healthier choices. Only some trials have focused on capacity building and macro-policy changes, such as the adaptation of the built environment of the school, serving smaller portion sizes and increasing the availability and accessibility of healthy foods and water in schools, and restricting access to vending machines, for example.

Multidimensional intervention studies are usually difficult to evaluate, and depend greatly on the complexity of evaluation designs (e.g. only outcome evaluation vs. complex evaluation including process, impact, and outcome). Moreover, especially in the multidimensional community-based programs it is hard to distinguish which part of the intervention was the most effective.

Overall, most of the intervention studies showed no consistent effects on changing BMI of children. A large amount of studies, mainly based on school interventions, did not show very effective results, which can be a reflection of the difficulties experienced trying to obtain significant results by relying only on school-based interventions. In fact, the small weight reductions described in most studies could be clinically irrelevant. It is hard to figure why the interventions taken until now prevent/reduce childhood obesity have failed to provide substantial results in terms of effectiveness. The ineffectiveness of some interventions may be due to insubstantial evaluation, or because studies have too short durations to detect appropriate outcomes, or, simply, because they do not work (100). Another possible explanation is the lack of interventions at multiple levels of determinants, mainly changing the environment (distal level). Importantly, little is known on the sustainability of interventions over time (100). However, other positive results, such as the change of dietary behaviors or physical activity performance have been described, and should not be discarded.

Actions to prevent childhood obesity need to be taken in multiple settings and incorporate a variety of approaches and involve a wide range of stakeholders (100). Complex interventions focused in environmental changes and the strengthening of individuals and communities as well as macro-policy changes seem to be promising strategies to reduce childhood obesity without increasing socioeconomic inequalities (101). The best approach should include the family context and contemplate early life determinants. An

approach that could be much more effective to prevent obesity is a combination of interventions that promote healthier diets and increase physical activities through society, rather than an approach focused solely on school environments (101). Focusing on mass media campaigns and political actions to prevent obesity by influencing people's eating choices and the increase of physical activities might be an effective approach to this problem (101).

Overall, sustained interventions are likely to be required at several levels – at an individual level in schools and community settings to effect behavioral change, and in sector changes involving different stakeholders (100).

In conclusion, creating environments supportive of healthier behaviors seems to be the best approach to mitigate the challenge that is obesity.

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8. Table 1. Summary of dietary interventions on childhood obesity and their main characteristics and results.

Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
School-based interventions					
Ballabeina study (72)	Switzerland, 2009	Cluster randomized controlled single blinded trial	Lessons on nutrition (balanced nutrition and healthy nutritional behaviors in a didactic way), physical activity program, media use and sleep, and adaptation of the built environment of the preschool.	Preschool children (mean 5.1 years) (n=652), the parents, and the teachers	No differences in children BMI were found between groups. However, the intervention group had a reduction in the %body fat, better motor agility, as well as benefits in reported physical activity, media use and eating habits.
Singh AS, et al. (73,74)	Netherlands, 2006	School-based trial	Educational component, with classes in biology and physical education, and computer-based information program; and an environmental component, with propositions such as serving smaller portion sizes in the canteen and healthier options, restrict access to vending machines, and food awareness by posters.	Students from the ages of 12-14 years (n=1108)	With a twelve-month follow-up, a reduction in the skinfold thickness of the intervention groups was found, as well as lower consumption of sugar-containing beverages, and less screen time (but only in boys).
Kain J, et al. (75)	Chile, 2004	School-based obesity-prevention trial	Weekly physical activity classes and classes on healthy nutrition for parents and students. Some environmental changes were also made, among them, school kiosks were instructed to offer healthier choices to students and shown how they could still remain lucrative.	Parents and students from 1st to 8th grade, 2141 schools in the intervention group and 945 in the control group	Reduction of BMI z-scores in boys and a better physical fitness in both genders. On the other hand, the modifications in the kiosks food availability did not seem to change the student's food choices.
Healthier Options for Public School children (HOPS) (76)	Florida, US, 2004-2006	Randomized trial	Modifications in the school menu, school gardens, and physical activity. Complementarily, there were healthy nutrition and physical activity lessons for the students and parents through monthly newsletters.	6 elementary schools (4588 children aged 6 to 13 years; 48% Hispanic)	After 2 years, a higher percentage of students who maintained a normal weight (under the 85 th percentile of BMI-for-age) was found in the intervention group (52.1%) when comparing with the control group (40.7%). Students in the intervention group had also an improved academic performance.
Shape up Somerville (77)	United States, (September 2003-June 2005)	Non-randomized controlled trial	Increase of physical activity opportunities around the school, like information on safe routes to school and walking to the school bus; modifications inside the school space, like new equipment for physical activities; dietary intervention like promotion of fresh fruit and vegetables and taste tests, posters with nutrient and health information, training of food staff, modification of food offers in restaurants according to the study guidelines.	1178 children (average 7,92 years) attending public school in three different communities from Somerville, Massachusetts	After 1 year, the BMI z-scores in the intervention group were 0.06 lower than the ones in the control group. There was a decrease in overweight and obesity and an increase in remission in both sexes in the intervention group. Study design did not included randomization of the intervention.

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Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
Bacardí-Gascon M, et al. (78)	Mexico, 2012	Randomized cluster controlled trial	Sessions discussing healthy lifestyles to the school board and the teachers, carried by nutritionists and physical activity professionals. In addition, there were interactive lessons to the children to increase their fruit and vegetables intake and physical activity practice, and to reduce intake of soda and high fat and salt containing snacks, while simultaneously lowering their TV watching time. There were also healthy eating sessions to parents.	532 school-aged children from 2 nd and 3 rd grade	By the six month of this study there was a greater decrease in BMI in the intervention group than in the control group (difference of -0,82 kg/m ² in children BMI), although it was not sustained after 18 and 24 months.
Foster GD, et al., 2008 (79)	USA	Multicomponent School Nutrition Policy Initiative	This initiative included the following interventions: school self-assessment, in which the schools suggested strategies like limiting the use of food as reward/punishment, promoting active recess, and serving breakfasts in the classrooms; training in nutrition education for the school staff and children; nutrition policies, like changing sold foods according to the Dietary Guidelines for Americans; social marketing; and parent outreach through nutrition educators in home and school association meetings/workshops.	1349 students in grades 4 through 6 from 10 schools	A 50% reduction in incidence of overweight was found. There were significantly less children in the intervention schools (7.5%) than in the control schools (14.9%) who became overweight after 2 years. There were no differences observed in the incidence or prevalence of obesity, nor in the remission of overweight or obesity after 2 years of follow-up.
Donnelly JE, et al., 1996 (80)	Nebraska, USA	2-year trial	Nutrition education, modified school lunches, and increased physical activity. The meals were planned according to the Lunchpower! Program aiming to reduce energy, fat, and sodium lunches, consistent with the objectives of Healthy People 2000. In addition, there were also nutrition classes (basic nutrition, the relationship between diet and general health, nutrition for proper growth and development, healthy food choices, snack alternatives, reducing fat in the diet, and food safety).	Students from grades 3 to 5 in two school districts in rural Nebraska (n=338)	After two years of intervention, the control school showed significantly greater total energy (9%) and total fat (25%). The control school also showed considerably greater values for sodium and smaller for fiber. Concerning the physical activity, the control school practiced significantly more outside of school compared to the intervention school. After 2 years of the intervention both schools showed no significant changes in the percentage of body fat, but a significant increase in the BMI.

Dietary interventions to prevent childhood obesity: a literature review

Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
Community-based interventions					
MOVE/me Muevo (82)	San Diego County, USA, 2014	Randomized community trial	Activities and phone calls from health coaches on how to: increase the consumption of vegetables and fruits; decrease the consumption of sugar-sweetened beverages; increase healthy food portions; reduce eating out and do healthier options when eating out; increase the availability and accessibility of healthy foods and beverages at home; reduce the screen time and avoiding eating in front of the TV; and increasing the number of family meals.	541 families with children between the ages of 5 and 8 years old	After 2 years, there was no significant differences between the control and the intervention group concerning BMI or waist circumference (82). Some changes were observed in the dietary domain, namely a reduction in fat and sugary beverages.
Romp & Chomp (83)	Australia, 2020	Community-based trial	Changes on the provision of water in childcare centers, childcare policies regarding healthy eating and physical activity; and teaching of skills in physical activity and nutrition to the childcare professionals. Amongst the nutrition interventions were: provision of some resources (lunch boxes, drink bottles, and social marketing material for kindergarten children); staff trained to reinforce nutrition messages and healthy eating choices for children aged 5 years; support given to the kindergartens to engage with parents on the topic of healthy eating and to provide support for staff to adopt and implement health and well-being/nutrition policies; access to dietitian and other allied health professionals through e-mails, phone calls and site visits; production and distribution of promotional materials (balloons, stickers, posters, postcards).	Children aged 0–5 y (n =12,000) and their families	After 3 years of intervention, the 3.5 years old subsample showed considerably lower mean weight, BMI, and z-score BMI and the 2 and 3.5 years old showed considerably lower prevalence of overweight and obesity in when compared with the baseline values. The intervention group also showed considerably lower intake of packaged snacks and fruit juice.

Dietary interventions to prevent childhood obesity: a literature review

Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
The Aventuras Para Niños Study (84)	Southern California, 2003	Randomized Community-based trial	Three arms: Family-only, a Community-only, or a Family+Community intervention. In the Family-only intervention professionals call/make home visits to discuss how to maintain a healthy diet, prepare meals, and be physically active. The Community-only intervention included improving the school's playgrounds, implementing salad bars, as well as community parks, displaying water bottles in the classrooms for the students, better physical education equipment and healthy menus for the children, all of this combined with spreading media messages through posters, news and point-of-choice messages in grocery stores, with health messages. The Family+Community included all described.	811 predominantly Mexican immigrant/Mexican-American mothers with children in kindergarten through second grade	No noteworthy main effects nor interactions for the family or community interventions were found. Therefore it is possible that there weren't any real effects for the family or community interventions in the BMI z-scores of the children compared with either of those circumstances alone. Despite the lack of significant effects on the children's BMI z-score, there were multiple obesity-related behaviors in this children that were changed by the family intervention, like an increased consumption of fruits and vegetables.
EPODE (Ensemble Prevenons l'Obésité Des Enfants/Together Let's Prevent Childhood Obesity) (85)	France, 2004	Community-based intervention	Societal process in which local environments, childhood settings and family norms become more supportive and facilitate the adoption of healthy lifestyles in children – enjoying healthy eating, active play and recreation.	Children aged 0–12 years, and their families, as well as a wide variety of local stakeholders in 10 French pilot communities	No known results

Dietary interventions to prevent childhood obesity: a literature review

Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
Pacific Obesity Prevention in Communities (OPIC) project (86,87)	Australia, Fiji, New Zealand and Tonga, over a period of 30 months, between 2004 and 2009	Community-based intervention	Interventions targeting reductions in the consumption of high sugar content drinks and energy-dense snacks and increasing structured and unstructured physical activity.	18 000 secondary-school children (aged 12–18 years), 300 stakeholders and partner organizations, 60 multi-professional research staff and 27 higher degree research students.	The authors state that the project can produce positive effects in diet and physical activity, but effects on childhood obesity are not clearly described.
Interventions through mass media					
TV ban/restrictions of commercials to kids in several countries (89) and Portugal (90)	Sweden, Norway, Denmark, Austria, Ireland, Australia, Greece, and Portugal, 2019	Mass-media based-intervention	Sweden has banned TV commercials to children under the age 12, and TV advertising to children. Norway, Denmark, Austria, Ireland, Australia, and Greece have also made some restrictions on commercials for children. Portugal approved a law to restrict advertising to children for foodstuffs and beverages of high energy value, salt, sugar, and saturated fatty acids content. This is applicable around pre-school, basic and secondary schools, in playgrounds or in the 100 meters around these locations, as well as these advertisements on television and radio programs broadcast in the 30 minutes before and after children's programs or with a minimum of 25% audience of children under 16, also applying to advertising broadcast on movie theaters in films for children under 16 and, on the Internet, on websites, pages or social networks, with content for this age group.	Children	No efficacy results. However, energy-dense foods and drinks and fast-food companies often target children in their advertisements, since they are very easily influenced in this ages, namely through TV commercials.

Dietary interventions to prevent childhood obesity: a literature review

Name/Author (reference)	Country, Year	Type of intervention	Intervention description	Target audience	Results
Food Sector					
Taxation of sugar-sweetened beverages (92,93)	Portugal, 2017	Food sector intervention	Taxation of sugar-sweetened beverages as an intervention to reduce its high consumption in the country.	Community	Decrease of 6.58 million liters per year using taxation, which translates into a decrease in consumption of 21% compared to the baseline consumption data of IAN-AF 2015–2016. The number of cases of obesity prevented had a higher impact in adolescents (0.012%), preventing 0.76 cases of obesity yearly, followed by an impact of 0.062% in adults aged 18 to <65 years, and the children showed an impact of 0.049%.. This data shows that Portugal achieved its goal, decreasing sales of sugar-sweetened beverages.
“Pick the Trick” program (94)	Australia and New Zealand	Food sector intervention	Providing foods with symbols for the consumers that make it easier to identify the healthier choices.	Community	No known results
WHO Single front-of-pack labelling system (95,96)	WHO European Food and Nutrition Action Plan 2015–2020	Food sector intervention	Among other future polices, there is the intention of application of a single front-of-pack labelling system in all countries.	Community	No known results