

The effects of physical activity and eating habits on obesity levels among children aged between 6 and 12 years old: systematic review

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Summary

Introduction: Physical activity and eating habits are variables to take into account for the analysis and correction of obesity problems. The objective of this review was to evaluate the effects of physical activity and eating habits on obesity levels in children between 6 and 12 years of age.

Material and method: A bibliographic search was carried out in the WOS and SCOPUS databases. The eligibility criteria were established based on the acronym PICOS: (P) basic education children between 6 and 12 years of age, (I) studies that carried out interventions of the nutritional component, the physical activity component or a combination of both of them. This in the school, sports and / or family environment, (C) be subjected to evaluation using the PEDRO scale and obtain a score equal to or greater than 7, (O) evaluate the effect of food programs and / or physical activity on childhood obesity, (S) randomized controlled studies, published between 2015 and 2020.

Results: 6,388 articles were identified, but only those that met the inclusion criteria were included. but only those that met the inclusion criteria (34 studies) were included. The most effective interventions were found to be those combined with a medium duration of intervention, and parental involvement and gender may influence the effectiveness of these interventions.

Conclusion: Interventions that consider the component of physical activity and eating habits together are the most effective in achieving a decrease in obesity levels in children 6 to 12 years of age.

Key words:

Feeding Habits. Physical Activity. Obesity. Children.

Palabras clave:

Actividad Física. Hábitos Alimenticios. Obesidad. Niños.

Efectos de la actividad física y hábitos alimenticios en los niveles de obesidad de niños entre 6 y 12 años: revisión sistemática

Resumen

Introducción: La actividad física y los hábitos alimentarios son variables a tener en cuenta para el análisis y corrección de los problemas de obesidad. El objetivo de esta revisión fue evaluar los efectos que tiene la actividad física y los hábitos alimentarios en los niveles de obesidad en niños entre 6 a 12 años de edad.

Material y método: Se realizó una búsqueda bibliográfica en las bases de datos WOS y SCOPUS. Los criterios de elegibilidad fueron establecidos en base al acrónimo PICOS: (P) niños de educación básica de entre 6 y 12 años de edad, (I) estudios que llevaran a cabo intervenciones del componente alimenticio, del componente de actividad física o una combinación de ambos. Esto en el ámbito escolar, deportivo y/o familiar, (C) ser sometidos a evaluación mediante la escala de PEDRO y obtener en esta un puntaje igual o superior a 7, (O) evaluar el efecto de los programas alimenticios y/o de actividad física sobre la obesidad infantil, (S) estudios controlados aleatorios, publicados entre los años 2015 y 2020.

Resultados: Se identificaron 6.388 artículos, pero solo se incluyeron los que cumplieron con los criterios de inclusión. pero solamente se incluyeron los que cumplieron con los criterios de inclusión (34 estudios). Se encontró que las intervenciones más efectivas fueron las combinadas con una duración de intervención media, y la participación de los padres y el sexo pueden influir en la efectividad de estas intervenciones.

Conclusión: Las intervenciones que consideran el componente de actividad física y hábitos alimenticios en conjunto son las más efectivas para lograr una disminución de los niveles de obesidad en niños de 6 a 12 años de edad

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Introduction

According to the World Health Organization (WHO),¹ non communicable diseases (NCD) are responsible for an annual mortality level of 41 million people, corresponding to 71% of deaths throughout the world. NCD are known as chronic diseases, they are generally long duration and have negative consequences in all age groups and all countries. They emerge due to the presence of various risk factors, such as modifiable behaviour and metabolic factors. In terms of metabolic risk factors, one of the main causes of death worldwide is rising blood pressure (19%), followed by excess weight and obesity. The latter is defined as an abnormal or excessive accumulation of fat that presents a health risk.²

According to Oyarce, *et al.*,³ this is characterised by an excessive increase in the percentage of body fat, produced by a positive energy balance sustained over time, capable of causing other diseases to appear, as mentioned by Schetz, *et al.*,⁴ who determine that depending on the degree, distribution and duration of the excess body fat, the health risks include the appearance of hypertension, type II diabetes, cardiovascular diseases, dyslipidaemia, chronic renal diseases, non-alcoholic fatty liver, obstructive sleep apnea or hypoventilation, physical and mood-related disorders. Regarding its prevalence throughout the world, Jaacks, *et al.*,⁵ mention that it has increased substantially over the last few decades from under 3% in 1975 to 11% in 2016 among men and from 6% to 15% among women; in the case of children, the increase went from 1% to 6-8% during the same period of time. In this context, the WHO⁶ highlights that child obesity has become one of the most serious public health issues in the 21st century. This worldwide problem is progressively affecting a large number of low and medium-income countries. Indeed, from 2014 onwards, the prevalence of obesity in subjects from 2 to 19 years old is 17%.⁷ In fact, it is calculated that in 2016, more than 41 million children aged under five throughout the world were overweight or obese.⁶ Chile has not escaped this phenomenon and excess weight and obesity have increased among schoolchildren and the population aged over 15 years old in Chile over the last few decades, despite prevention work.⁸ Furthermore, according to Sapunar, *et al.*,⁹ this progressive increase in the prevalence of disorders due to overnutrition has become one of the highest in the world. Something similar has happened among the child-youth population both in Santiago and in the regions. In fact, Bustos, *et al.*¹⁰ mention that the Junta de Auxilio Escolar y Becas (School Assistance and Grants Board) (JUNAEB), a Chilean Government institution, demonstrated that, during 2013, the obesity level among children aged 6 who were attending the first year of basic schooling was 25.3%. In general terms, low levels of physical activity and an increase in sedentary behaviour are the most important causes of obesity. Indeed, according to Blanco, *et al.*,¹¹ there is a direct relationship between sedentary behaviour and fat accumulation. In this respect, Aguilar, *et al.*¹² indicate that physical activity corresponds to any body movement performed by the skeletal muscles that requires energy such as tasks performed every day in the

home, work, leisure and transport. It can provide various benefits for mental and physical health when children do 60 minutes of moderate to vigorous physical activity per day. Despite these benefits, Watson, *et al.*¹³ show that more than 50% of the child population in Australia and internationally do not meet these recommendations. This data is a cause for concern, due to findings which suggest that functional limitations, subjective well-being, social support, memory, depression and age are associated with physical inactivity and are therefore potential factors on the path to poor health.¹⁴ According to Gallota, *et al.*,¹⁵ the prevalence of inappropriate eating habits such as consuming many snacks and sugary drinks mid-morning, skipping breakfast, eating less fruit and/or vegetables can cause an increase in weight among children. Regarding the latter, Seidell and Halberstadt¹⁶ suggest that the increase in obesity levels in most countries seems to be mainly caused by changes to how food is supplied worldwide, offering a larger quantity of processed food which is more affordable and more widely sold than before. There are various definitions of eating habits, due to a wide variety of concepts. However, according to Pereira-Chávez, *et al.*,¹⁷ most concur that these are frequent manifestations of individual and collective behaviour that is acquired directly and indirectly and that are related to what is eaten, how, when, with what, for what and who eats the food.

Based on Viljakainen, *et al.*,¹⁸ a healthy diet, based on appropriate consumption of fruit, vegetables, fish, poultry, whole cereals and low-fat dairy products reduce the risk of obesity in adult and paediatric populations while an unhealthy diet rich in processed meat, refined cereals, sweets, food containing starch and high fat dairy products has been associated with excess weight. Consequently, eating habits recommended for children must provide the necessary energy, nutrients and bioactive compounds to keep them in good health.¹⁹ These data raise the following questions:

What are the effects of physical activity on obesity in children between 6 and 12 years old?

What are the effects of eating habits on obesity in children between 6 and 12 years old?

In this context, the aim was to evaluate the effects of physical activity and eating habits on obesity levels in children between 6 and 12 years old.

Material and method

Search strategy

This study is a systematic review that followed the PRISMA guide and the PICoR questions model to select the keywords. A search was performed on the Cochrane Library, Pubmed, and Wiley Library databases, that included papers published from 2015 to 2020. The search criteria included logically combining the DeCS search terms, using the respective Boolean search engines. Consequently, the following keywords were used for the search: "Eating habits", "Physical activity", "Obesity" and "Children" in Spanish and English. The information search and extraction took place between August and October 2020, and it was

stored in the Mendeley bibliographic quotes manager. The results were filtered by documents with the main theme of evaluating the effects of eating habits and physical activity on child obesity levels.

Inclusion criteria

- Random controlled studies, so that the study groups have equivalent characteristics, and any possible selection bias is avoided.
- Topics address eating habits, use of diets, physical activity and multidisciplinary interventions that included these variants, to treat excess weight or obesity and their effect on these factors in children aged between 6 and 12 years old, both female and male.
- Some type of result is obtained regarding indicators related to obesity.
- Once the search had been run, the quartile (Q) of the journal was identified, selecting any that are Q1 and Q2 in the Scopus database.
- Researchers from this systematic review have methodologically assessed it using the PEDro scale to quickly identify studies that tend to be validated internally and which have sufficient statistical information to develop this review.

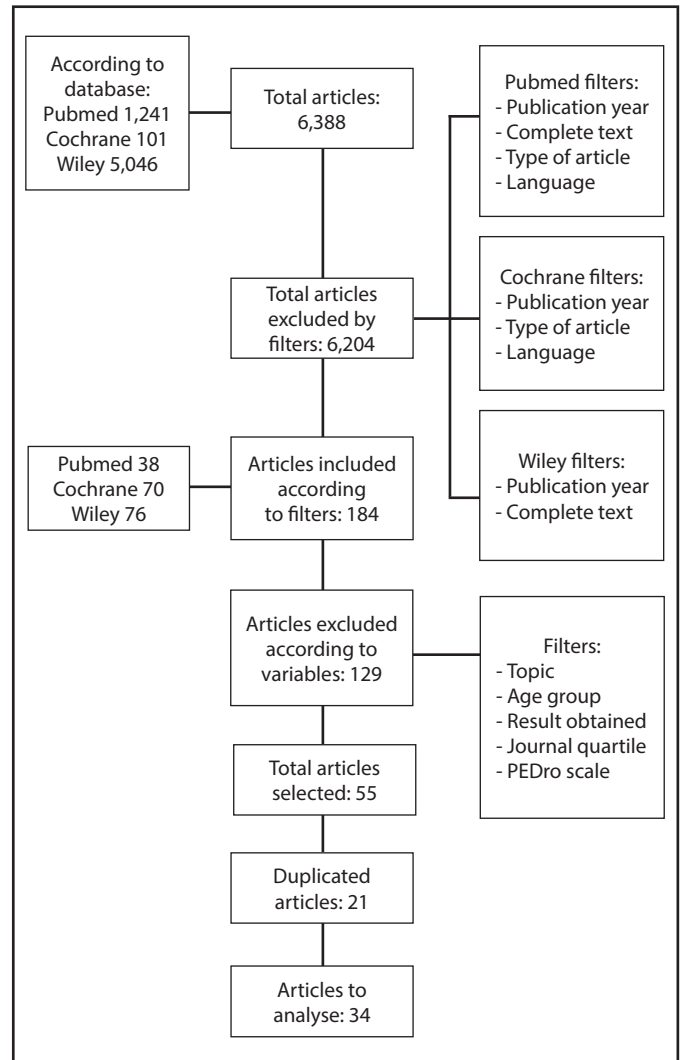
All articles that did not meet these criteria were excluded. A total of 6,388 articles were identified on the "Pubmed", "Cochrane Library" and "Wileylibrary" platforms, (1,241, 101 and 5,046 studies respectively). The total number of articles excluded by the platform filters was 6,204, including 184 studies to be reviewed, which were verified by title, keywords and study abstract. From this quantity, 128 studies were excluded due to the initially-categorised variables (age group, result obtained, unrelated studies), leaving a total of 56 selected studies of which 21 were duplicated, concluding with the total of 34 articles included in this research (Figure 1).

Results

Data was extracted from the selected articles that met the inclusion criteria. Tables 1 and 2 describe relevant information from the studies, identifying the name of the research, authors and year of publication, plus its duration, location and results of the intervention.

34 random controlled studies were included. To define the ranges in relation to the time frames corresponding to the research, we call on the standard used in the systematic review of Effective techniques for changing behaviour for physical activity and healthy eating among adults who are overweight or obese.⁵³ Short-term research (n = 15) refers to lasting 6 months or less (44.12%), medium-term (n = 7) lasts over 6 months, but under 12 months (20.59%), and long-term (n = 11) refers to research lasting for 12 months or more (32.35%). One study did not specify how long it lasted (2.94%). The sample size makes it possible to demonstrate how many individuals must be studied to be able to detect a certain difference between the groups. Female and male children took part in the following review and the highest research sample size was 10,091, compared to the lowest which was 29.

Figure 1. Process for including the articles.



The included studies consisted of 34 random controlled studies. A large number of them (n = 12) took place in Europe (35.29%), followed by North America with 9 studies (26.47%), and Asia also with 9 studies (26.47%), Oceania with 2 (5.89%), Africa 1 (2.95%) and South America also with 1 study (2.9%).

The included studies involved interventions on the food component, physical activity and a mixed component. Seven studies carried out interventions on physical activity without a food intervention (20.5%). The same number of studies (n = 7) only carried out interventions on the food component (20.5%). Twenty studies carried out mixed or multidisciplinary interventions, that included both the food and the physical activity component (59%). These included studies produce different results relating to different anthropometric values for the study subjects, such as body weight, body mass index (BMI), body fat percentage, waist circumference, skin folds, body lean mass and fat mass; plus statistical

Table 1. Duration of the intervention and sample size.

Authors and year	Duration	Sample size (n)
Kühr, <i>et al.</i> (2020) ²⁰ Denmark	5 years	1,299
Cao, <i>et al.</i> (2015) ²¹ China	33 months	2,446
Ochoa-Avilés, <i>et al.</i> (2017) ²² Ecuador	28 months	1,430
Hollis, <i>et al.</i> (2016) ²³ Australia	24 months	1,150
Katan, <i>et al.</i> (2016) ²⁴ Netherlands	18 months	641
Makkes, <i>et al.</i> (2016) ²⁵ Netherlands	12 months	80
Cohen, <i>et al.</i> (2016) ²⁶ Canada	12 months	78
Adab, <i>et al.</i> (2018) ²⁷ United Kingdom	12 months	2,562
Anderson, <i>et al.</i> (2017) ²⁸ New Zealand	12 months	203
Fulkerson, <i>et al.</i> (2015) ²⁹ United States	12 months	160
Li, <i>et al.</i> (2019) ³⁰ China	12 months	1,641
Xu, <i>et al.</i> (2015) ³¹ China	1 academic year	1,182
Wang, <i>et al.</i> (2018) ³² China	1 academic year	10,091
Keszytüs, <i>et al.</i> (2017) ³³ Germany	1 academic year	1,733
Lima, <i>et al.</i> (2020) ³⁴ Switzerland	9 months	499
Sánchez-López, <i>et al.</i> (2020) ³⁵ Spain	9 months	108
Serra-Paya, <i>et al.</i> (2015) ³⁶ Spain	8 months	113
Yu, <i>et al.</i> (2020) ³⁷ China	8 months	171
Boutelle, <i>et al.</i> (2017) ³⁸ United States	6 months	150
Bibiloni, <i>et al.</i> (2019) ³⁹ Spain	6 months	140
Yusop, <i>et al.</i> (2018) ⁴⁰ Malaysia	6 months	50
Staiano, <i>et al.</i> (2018) ⁴¹ United States	6 months	46
Seo, <i>et al.</i> (2019) ⁴² Korea	4 months	103
Nicolucci, <i>et al.</i> (2017) ⁴³ Canada	4 months	42
Ahmad, <i>et al.</i> (2018) ⁴⁴ Malaysia	4 months	134
Koo, <i>et al.</i> (2018) ⁴⁵ Malaysia	3 months	83
Moschonis, <i>et al.</i> (2019) ⁴⁶ Greece	3 months	80
Cvetković, <i>et al.</i> (2018) ⁴⁷ United States	3 months	42
Muller, <i>et al.</i> (2019) ⁴⁸ South Africa	2.5 months	746
Morell-Azanza, <i>et al.</i> (2019) ⁴⁹ Spain	2 months	121
Ojeda-Rodríguez, <i>et al.</i> (2018) ⁵⁰ Spain	2 months	107
Wang, <i>et al.</i> (2019) ³² United States	1.5 months	110
Bogart, <i>et al.</i> (2016) ⁵¹ United States	5 months	4,022
Baum, <i>et al.</i> (2015) ⁵² United States	Not indicated	29

results such as the BMI z-score, body weight z-score, probability of developing obesity and percentage of individuals with normal weight. Furthermore, some studies revealed results on fat oxidation levels and triglyceride levels (Table 3).

The included studies comprised 34 random controlled studies. 7 of them only performed interventions on the food component, of which 4 carried out a direct intervention on the food intake by the study subjects (11.8%) while the remaining 3 were based on recommendations and theory classes on this component (8.8%).

Table 2. Types of interventions and results obtained in the studies.

Authors and year	Intervention	Results
Wang, <i>et al.</i> ³² (2018) China	Physical activity	Lower BMI and probabilities of obesity
Kühr, <i>et al.</i> ²⁰ (2020) Denmark	Physical activity	Lower BMI and WC
Cvetković, <i>et al.</i> ⁴⁷ (2018) United States	Physical activity	Trivial drop in body mass, increase in muscle mass, lower fat mass and BMI.
Hollis, <i>et al.</i> ²³ (2016) Australia	Physical activity	Lower average weight and BMI
Muller, <i>et al.</i> ⁴⁸ (2019) South Africa	Physical activity	Smaller increase in average BMI-z and a smaller increase in the average thickness of skin folds.
Lima, <i>et al.</i> ³⁴ (2020) Switzerland	Physical activity	Smaller sum of skin folds
Staiano, <i>et al.</i> ⁴¹ (2018) United States	Physical activity	Lower BMI z-score. Better LDL and total cholesterol
Fulkerson, <i>et al.</i> ²⁹ (2015) United States	Physical activity	Drop in excess weight. Lower BMI z-scores. Drop in weight gain for overweight children
Wang, <i>et al.</i> ⁵⁴ (2019) United States	Dietetics	Lower BMI-z, increase in physical activity, consumption of fruit and vegetables
Baum, <i>et al.</i> ⁵² (2015) United States	Dietetics	Increase in fat oxidation, satiation, less hunger.
Katan, <i>et al.</i> ²⁴ (2016) Netherlands	Dietetics	Lower increase in the BMI z-score and body weight. Drop in body fat in the high BMI group.
Nicolucci, <i>et al.</i> ⁴³ (2017) Canada	Dietetics	Lower z-score for body weight, the percentage of body and trunk fat
Koo, <i>et al.</i> ⁴⁵ (2018) Malaysia	Dietetics	Lower percentage of body fat, WC
Ochoa-Avilés, <i>et al.</i> ²² (2017) Ecuador	Dietetics	Drop in WC after stage one
Bogart, <i>et al.</i> ⁵¹ (2016) United States	Dietetics	Reduction in the BMI percentile for obese students after 2 years
Moschonis, <i>et al.</i> ⁴⁶ (2019) Greece	Mixed	Lower BMI and BMI z-score. Less increase in body weight and WC
Xu, <i>et al.</i> (2015) ³¹ China	Mixed	Lower BMI and increase in the chances of reducing the BMI
Makkes, <i>et al.</i> ²⁵ (2016) Netherlands	Mixed	Lower BMI-SD due to an average weight loss
Ojeda-Rodríguez, <i>et al.</i> ⁵⁰ (2018) Spain	Mixed	Lower body weight, BMI-SD, glucose, total cholesterol levels and total energy intake

(continued)

Table 2. Types of interventions and results obtained in the studies (continuation).

Authors and year	Intervention	Results
Yusop, et al. ⁴⁰ (2018) Malaysia	Mixed	Lower BMI z-score. Increase in the physical activity level from low to moderate.
Cohen, et al. ²⁶ (2016) Canada	Mixed	Lower BMI z-score and fat mass percentage. Lower fat mass and increase in lean mass
Bibiloni, et al. ³⁹ (2019) Spain	Mixed	Overweight participants changed to normal weight after 6 months
Sánchez-López, et al. ³⁵ (2020) Spain	Mixed	Drop in the percentage of average body fat, average BMI and kilograms of body fat
Adab, et al. (2018) ²⁷ United Kingdom	Mixed	Average BMI z-score was lower in the intervention group
Anderson, et al. ²⁸ (2017) New Zealand	Mixed	Significant drop in the BMI-SD
Li, et al. ³⁰ (2019) China	Mixed	Lower BMI z-score and fat percentage
Ahmad, et al. ⁴⁴ (2018) Malaysia	Mixed	Lower BMI z-score and body weight. Smaller increase in the average WC percentile
Cao, et al. ²¹ (2015) China	Mixed	Drop in the prevalence of obesity and BMI z-score. Increase in the percentage of individuals with normal weight
Boutelle, et al. ³⁸ (2017) United States	Mixed	Lower BMI-z
Kesztyüs, et al. ³³ (2017) Germany	Mixed	Drop in the BMI percentile and the probabilities of developing abdominal obesity during the study period.
Morell-Azanza, et al. ⁴⁹ (2019) Spain	Mixed	Drop in the BMI-SD and hip circumference
Seo, et al. ^{37,42} (2019) Korea	Mixed	Lower BMI-z, fat mass and blood pressure
Yu, et al. ³⁷ (2020) China	Mixed	Drop in the risk of metabolic anomalies. Lower increase in TG.
Serra-Paya, et al. ³⁶ (2015) Spain	Mixed	Drop in BMI-d and increase in physical activity

Seven studies performed interventions on physical activity without a food intervention, and all of them carried out a direct intervention that implied doing different types of physical activity at different frequencies (20.5%).

The other studies (n = 20) carried out mixed interventions, of which 4 were based on recommendations and theory sessions on these com-

ponents (11.8%) while the remaining 16 (47.1%) carried out a direct intervention on the subjects' food and their levels of physical activity.

Discussion

34 random studies were analysed that examined the effect of eating habits and physical activity to address excess weight and obesity in children aged between 6 and 12. Research was included with an intervention time from 5 weeks to 5 years, consequently, it was classified into short-term (44.12%), medium-term (20.59%) and long-term (32.35%) to ease data interpretation. Only one study did not present an intervention time (2.94%). The interventions in the included studies varied from short to long term, mainly in relation to sample size, as the average for long-term research is 1,062 participants, as opposed to medium-term, where the average was 1,985 and short-term with an average sample size of 373 participants. In relation to this data, Das, et al.⁵⁵ state that a correct sample size reduces the random error or prevents chance events. Furthermore, samples which are too small in general do not answer the research questions and can deliver an inaccurate answer. On the contrary, while a large sample does deliver answers to the research questions, it might not be particularly ethical. Based on this topic, Heidel⁵⁶ suggests that the larger the sample size, the higher the chances of detecting significant effects, that make it possible to detect small and large effect sizes, independently of their respective variations. However, this is counter-balanced by Sones, et al.,⁵⁷ who state that large sample studies can waste a large number of resources and in turn, can give false results. On the other hand, out of the 34 research projects included, 21 (61.76%) demonstrated a greater effect on obesity indicators. Out of these 21, 6 were long-term, 2 were medium-term and the largest concentration of studies with important effects was 13, which were short-term. This indicates that the most effective type of interventions usually last 6 months or less. This data contrasts with Aguilar, et al.⁵⁸ who suggest that short-term interventions or any that take place outside the children's daily activities, produce a clear rebound effect in the results obtained. To this we can add that, regarding the location of the selected studies, most of the interventions took place in Asia or Europe, and our continent (South America) presented the smallest number of studies of this type. This means that more interventions are required to evaluate whether the benefits observed in the review studies are just as effective among children with the genetic, environmental and sociocultural characteristics found in our country, as in the case of the pilot study by Mardones, et al.⁵⁹, which implemented an intervention based on physical activity among school children aged 6 and 7 years old, obtaining favourable results in variables such as blood pressure and waist circumference. This need increases, because South American countries demonstrate particular characteristics related to eating habits and physical activity, as indicated in the study by Louzada, et al.⁶⁰ which mentions that ultra-processed food represented 30% of the total energy contribution in Brazil, and this correlated with high BMI levels. On the

Table 3. Effectiveness of the physical activity programmes and nutritional mediation.

Authors and year	Physical activity intervention	Nutritional mediation
Wang, <i>et al.</i> (2017) China	Study plans in the classroom, support for the school environment, family participation and fun programmes/events.	None
Kühr, <i>et al.</i> (2019) Denmark	4.5 hours of physical education classes a week	None
Cvetković, <i>et al.</i> (2018) United States	HIIT training and recreational football	None
Hollis, <i>et al.</i> (2016) Australia	Teaching strategies for physical activity (PA), PA plans, school sports programme, PA exhibitions and PA programmes during the school holidays.	None
Muller, <i>et al.</i> (2019) South Africa	Two 40-minute physical education lessons per week; one 40-minute music and movement per week; regular physical activity breaks in class; setting up activity stations and a variety of playground painted games.	None
Lima, <i>et al.</i> (2020) Switzerland	Two additional physical education lessons per week.	None
Staiano, <i>et al.</i> (2018) United States	Videogames that implicate physical activity, plans for game studies and videochat sessions with a physical trainer.	None
Fulkerson, <i>et al.</i> (2015) United States	None	Family-based change in the planning, frequency and healthy aspect of meals.
Wang, <i>et al.</i> (2019) United States	None	Group sessions on nutrition
Baum, <i>et al.</i> (2015) United States	None	Eating protein-based breakfasts
Katan, <i>et al.</i> (2016) Netherlands	None	Replacing sugary drinks with non-calorific drinks
Nicolucci, <i>et al.</i> (2017) Canada	None	Intake of prebiotic doses (8 g a day)
Koo, <i>et al.</i> (2018) Malaysia	None	Nutritional education classes and handing out wholemeal food
Ochoa-Avilés, <i>et al.</i> (2017) Ecuador	None	Classes and workshops on healthy eating, workshops for parents and preparing healthy breakfasts.
Bogart, <i>et al.</i> (2016) United States	Encouraging physical activity using posters, short films,	Stimulus for eating healthy food in the school canteen, education and peer-based marketing
Moschonis, <i>et al.</i> (2019) Greece	Physical activity recommendations	Personalised eating plans and nutritional recommendations
Xu, <i>et al.</i> (2015) China	Lessons on physical activity, posters to promote physical activity and lessons for parents or tutors.	Lessons on healthy eating, posters to promote healthy eating and lessons for parents or tutors.
Makkes, <i>et al.</i> (2016) Netherlands	Sessions on physical activity and sports games	Classes on nutrition
Ojeda-Rodríguez, <i>et al.</i> (2018) Spain	Physical activity recommendations	Use of the Mediterranean diet and nutritional recommendations
Yusop, <i>et al.</i> (2018) Malaysia	Aerobic training sessions	Nutritional advice and a practical activity to prepare healthy food
Cohen, <i>et al.</i> (2016) Canada	Family advice sessions on physical activity, 60 minutes of activity per day based on jumping, running or light strength-training activities.	Family-based sessions on nutritional advice, consumption of 2 to 4 portions of dairy per day, colour coding food according to calorie content
Bibiloni, <i>et al.</i> (2017) Spain	5 or more hours of physical activity in a sports centre.	Use of the Mediterranean diet, attending dietary clinics.
Sánchez-López, <i>et al.</i> (2020) Spain	90-Minute physical activity sessions based on games	Theoretical sessions and nutritional advice practice
Adab, <i>et al.</i> (2018) United Kingdom	Recommendations for physical activity, one additional class per week of physical activity lasting 30 minutes at school, interactive programme with a football club.	Family workshops on healthy cooking.

(continued)

Table 3. Effectiveness of the physical activity programmes and nutritional mediation (continuation).

Authors and year	Physical activity intervention	Nutritional mediation
Anderson, et al. (2017) New Zealand	Family-based physical activity sessions, including sports chosen by the participants.	Assessment evaluations for all participants, through virtual paths round supermarkets, cooking sessions, portion sizes, and concept of healthy food.
Li, et al. (2019) China	Moderate to Vigorous Physical Activity sessions (MVPA)	Lessons and encouragement for healthy eating behaviour inside and outside school.
Ahmad, et al. (2018) Malaysia	Exercise session of moderate to intense physical activity lasting at least 30 minutes and up to 120 minutes of screen time (TV or videogames).	Skills training for parents on their children's diet through specific daily behaviour for the child such as avoiding sugary drinks and unhealthy snacks, eating at least five portions of fruit and vegetables (two portions of fruit and three portions of vegetables).
Cao, et al. (2015) China	Weekly exercise sessions by applying the 20-metre musical shuttle, 2 or 3 times a week. Ensuring the participation rate for regular physical education at school and out of school activities. More than 1 hour of physical activity every school day and outstanding sports activities such as skipping and football.	Monitoring students' eating speed during lunch and advice on how to eat less junk food. Reducing the fat content in food in the canteen and making sure that there are more fruit and vegetables available.
Boutelle, et al. (2017) United States	Recommendation of moderate to vigorous physical activity to parents, to apply to their children.	It was assessed with three dietary reminders with multiple 24-hour passes in 3 non consecutive days through a phone interview. The total energy intake was calculated using the Nutrition Data Systems for Research software.
Kesztyüs, et al. (2017) Germany	Physical activity sessions, focussed on parents and children, from moderate to vigorous intensity.	Guidance to reduce the intake of sugary drinks.
Morell-Azanza, et al. (2019) Spain	Individual and group sessions of moderate to vigorous physical activity with weekly measuring using an axial accelerometer.	High consumption of fruit (3 portions a day), vegetables (2 portions a day), pulses, whole grains and olive oil; moderate consumption of dairy, poultry and fish, and less processed and red meat, limited to 1 portion per week.
Seo, et al. (2019) Korea	Assessment related to physical exercise by health professionals. All the participants received instructions to walk more than 8000 steps a day and they were sent a text message once a week to encourage daily physical activity.	Personalised medical advice, providing a workbook to set goals and change behaviour, assessment on personalised nutritional advice.
Yu, et al. (2020) China	Compulsory daily exercise was implemented. This consists of a 20-minute break in classes in the morning to go jogging. An additional gym class (40 min) after school in the afternoon included three types of exercises (skipping, badminton and 200 m relay races).	Promoting intake of healthy food and developing healthy eating habits.
Serra-Paya, et al. (2015)	The programme offered 90 one-hour sessions (3 per week) of moderate physical activity for children.	Guidance and assessment on consumption of fruit, processed meat, excess food and soft drinks.

other hand, the study performed in Chile by Delgado-Floody, et al.⁶¹ determined that physical condition variables differed significantly between the study subjects, which were 100 children aged between 12 and 15. This variable has an inverse relationship with obesity levels according to Zurita-Ortega, et al.,⁶² which included a group of children with an average age of 10.5 years old and it established a negative relationship between the BMI and the maximum oxygen consumption, jumping ability, physical activity and self-esteem among these subjects. Apart from this, the socio-economic situations are varied and differ from other continents, which might affect obesity levels,⁶³ where it indicates that the socio-economic level in childhood influences the body mass index, waist circumference and obesity in adults, and that this relationship

would differ between genders. All the studies included (n=34) provided information on some type of effect of the intervention on at least one indicator related to obesity, where BMI and values related to this indicator, such as the BMI z-score (BMI-z) and the standard deviation of the BMI (BMI-SD) are the most common focus. In turn, it was identified that the higher number of studies which obtained significant results (n = 21) had a mixed intervention (n = 15), which indicates that interventions combining the physical activity component and the diet component are the most effective to address child obesity. These findings are consistent with other similar research, such as Thakur, et al.⁶⁴, which demonstrated that a package of lifestyle interventions based at school had a favourable effect on the anthropometric parameters in a group of

children with the average age of 13 years old. There is also the study by Ranucci, *et al.*,⁶⁵ which demonstrates the efficacy of a multidisciplinary intervention in reducing the cardiometabolic risk, significant drop in BMI, body fat percentage and waist circumference in children (5 to 12 years old); and in the case of teenagers (13 to 17 years old), a drop in waist circumference (WC) and body fat percentage.

In turn, this is explained by the results obtained in a study in Spain by Ruiz, *et al.*,⁶⁶ which indicate that excess calorie intake is not the main reason explaining the high predominance of excess weight or obesity, but it goes hand in hand with a sedentary lifestyle and low levels of physical activity. Interventions carried out on the study subjects were run or jointly run mainly by school staff (teachers), external professionals who specialise in health (dietitians, nurses, paediatricians, psychologists, physiotherapists, nutritionists, doctors, sports medicine specialists), in the social area (social workers), in the physical activity area (physical trainers), by research personnel, university students or leading colleagues. In some cases, there was a combination of different types of professionals. Only one study did not specify who performed the intervention, only that it was supervised by research personnel. The implementation of interventions that involved a multidisciplinary approach regarding the professionals in charge were demonstrated to be effective to address obesity, which concurs with the indications provided by Fitzpatrick, *et al.*,⁶⁷ determining a model for handling obesity in primary care, based on the 5A assessment framework (assess, advise, agree, assist and arrange), and in its second point, they indicate that: a multidisciplinary team is required to help patients lose weight and maintain their weight loss. In the same way, studies are included that consider participation from family members (parents or tutors) in the applied intervention ($n = 26$), of which 18 correspond to studies that had an important effect on the obesity indicators. This inclusion is upheld by Gerards, *et al.*,⁶⁸ who mention that focussing on styles of child-raising seems to be effective to prevent or treat child obesity and thereby improve the results for children and parents, and also the eating habits and levels of physical activity for the children. Based on the studies that include parents or tutors as mentioned above, the majority demonstrate positive effects on modifying indicators related to obesity. This is upheld by a study performed in Korea, where the results obtained indicate that a parent participation programme combined with an exercise and nutrition intervention for the children was more effective for both parents and children than the intervention only offered to children.⁶⁹

In the same way, Ek, *et al.*⁷⁰ implemented an intervention for parents of obese children aged between 4 and 6, which was demonstrated to be more effective than the standard treatment for obesity in pre-school children, after 12 months. In fact, it was seen to be 5 times more likely to get a clinically significant drop in the BMI-z score compared to the standard treatment. Within our study, we can see certain limitations that mainly lie in low sample sizes and the short duration of some interventions, which might not identify significant relationships between the intervention and the effect. Furthermore, few studies were carried out

in continents such as Oceania, Africa and South America, to confirm results in more varied samples with different ethnic and racial origins, where behaviour and cultural beliefs differ regarding physical activity and eating habits.

Conclusion

According to the data analysed in this systematic review, it can be concluded that interventions which jointly consider the physical activity and eating habit components are the most effective to lower obesity levels among children aged 6 to 12 years old, recommending an intervention duration of 6 months or less, carried out by a multidisciplinary group of professionals and including participation from parents, to guarantee good results.

Authorship contribution

All the authors of this paper have taken part in the design, search for information, interpretation of the information, writing the text in all the versions completed and finally in the approval of the final version of the paper.

Conflict of interests

The authors do not declare any conflict of interests.

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