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A systematic review of the effects of nutrition programmes in high schools

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Abstract **Introduction/Objective:** Obesity rates are reaching alarming levels. Adolescence is a critical period for the prevention of nutritional problems, as it is a time of development of one's own eating habits. These habits will persist into adulthood, so showing adolescents healthy lifestyle patterns is important. The ideal option would be through school-based nutrition intervention programmes. The main objective of this article is to investigate the effectiveness of intervention programmes based on nutritional knowledge and the behaviour of adolescents aged 11-19 years. **Method:** To carry out this systematic review we employed Scopus, PubMed, and Web of Science as databases and a search period that spanned the last 10 years, following the PRISMA statement. Subsequent to the search, 110 articles were found. Finally, 19 articles were selected for in-depth analysis after a thorough screening. **Results:** The results show that, in general, intervention programmes have improved the nutritional knowledge of high school students, which means an improvement in their eating behaviours. In addition, these programmes increase their levels of physical activity. However, gender differences are observed, with girls being more concerned about maintaining a balanced diet**. Conclusion:** In conclusion, schools are an ideal environment for developing programmes that interfere in adolescent eating behaviour.

Una revisión sistemática de los efectos de los programas de nutrición en educación secundaria

PALABRAS CLAVE
Alimentación,
salud,
programas de intervención,
actividad física,
conocimiento nutricional,
conductas alimentarias

Resumen **Introducción/Objetivo:** Las tasas de obesidad están alcanzando niveles alarmantes. La adolescencia es un periodo crítico para la prevención de problemas nutricionales, ya que es un momento de desarrollo de los propios hábitos alimentarios. Estos hábitos permanecerán en la edad adulta, por lo que es importante mostrarles a los adolescentes patrones de estilo de vida saludable. La opción ideal sería a través de programas de intervención nutricional en las escuelas. El objetivo principal de este artículo es investigar la efectividad de los programas de intervención basados en el conocimiento y comportamiento nutricional en adolescentes de 11 a 19 años. **Métodos:** Para llevar a cabo esta revisión sistemática utilizamos como bases

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de datos Scopus, PubMed y Web of Science y un periodo de búsqueda que abarcó los últimos diez años, siguiendo la declaración Prisma. Después de la búsqueda, se encontraron 110 artículos. Finalmente, 19 artículos fueron seleccionados para un análisis en profundidad después de una revisión exhaustiva. **Resultados:** Los resultados muestran que, en general, los programas de intervención han mejorado los conocimientos nutricionales de los estudiantes de secundaria, lo que significa una mejora en sus conductas alimentarias. Además, estos programas aumentan sus niveles de actividad física. Sin embargo, se observan diferencias de género, estando las chicas más preocupadas por mantener una dieta equilibrada. **Conclusiones:** En conclusión, las escuelas son un ambiente ideal para el desarrollo de programas que interfieren en la conducta alimentaria de los adolescentes.

The Global Nutrition Report (2022) apprises that the level at which obesity rates and nutrition-related diseases are increasing is alarming. In fact, it is estimated that 254 million children and adolescents will have obesity problems by 2030 (Finkelstein et al., 2012). In consensus with Dhauvadel et al. (2019), the reason is that adolescents do not have adequate knowledge regarding their nutritional needs and the quality of their diet is quite poor.

Adolescents are considered a vulnerable group due to the high nutritional requirements for growth, reproductive maturation, and cognitive transformations (Das et al., 2017). In addition, unfavourable changes in food consumption patterns and lifestyle, risky eating behaviours, and susceptibility to environmental influences are observed (Moitra & Madan, 2022). Adolescents develop their own eating habits, which may persist in adult life (Patton et al., 2016). Adolescence is therefore a critical period for the prevention of weight problems and obesity (Langford et al., 2015).

Weight problems in adolescence: Causes

In recent times the influence of environmental changes has increased the prevalence of obesity among teenagers (Jebeile et al., 2022). Dietary factors contributing to the risk of obesity in this population group include the consumption of ultra-processed foods or sugary drinks (Ishak et al., 2016), driven by pervasive marketing and advertising (Liu et al., 2019; Mahumud et al., 2021). The food industry uses the media to promote unhealthy food and beverages (Popkin, 2015). Not only the advertisements in the media but also Information and communication technologies and food delivery online platforms influence people to consume this type of food and drinks (Indrayana & Palupi, 2014). Moreover, Robinson et al. (2017) stated that a large amount of daily screen time means that sedentary time increases at this age, while physical activity levels decrease. Unfortunately, children spend a lot of time using their electronic gadgets instead of doing exercise (Bentley et al., 2016).

Weight problems in adolescence: Consequences

Adolescents who are overweight or obese face physical, mental, and social health problems, both in the short and long term (Sagar & Gupta, 2018). Depression, stress (Roy et al., 2021), low self-esteem, anxiety (Fox et al., 2016), behavioural problems, and bullying (Waasdorp et al., 2018) are some of the consequences suffered by adolescents with weight problems. In addition, Gow et al. (2020) affirmed that they have a negative body image and lower body satisfaction. Obesity during childhood contributes to later adulthood obesity too (World Health Organisation, s.f.a).

According to the World Health Organisation (2021), obesity and weight problems also lead to serious health problems such as type 2 diabetes, cardiovascular diseases, musculoskeletal disorders, and various forms of cancer, among others. In this sense, 17.9 million people die every year because of cardiovascular diseases (World Health Organisation, s.f.c). These illnesses can be caused by an unhealthy lifestyle (American Heart Association, 2015) which is considered a risk factor.

Studies related to effects of nutrition programs in schools

Previous studies have shown that nutrition intervention programmes improve adolescents' nutritional knowledge and food consumption patterns (Sharif et al., 2020), leading them to make healthy dietary choices in their daily lives (Medeiros et al., 2022). In fact, Gómez et al. (2019) support the idea that educational programmes improve not only their nutritional knowledge but also their adherence to the Mediterranean diet in primary school students. In this sense, Gámez-Calvo et al. (2022) and Collado-Soler et al. (2023) carried out a systematic review of intervention programmes at that stage. Gámez-Calvo et al. (2022) found that most of the intervention programmes modify eating behaviours and increase the level of physical activity in children. Further, Collado-Soler et al. (2023) affirm that these types of programmes improve students' knowledge and healthy habits.

What's more, Lundborg et al. (2022) search for the long-term effects of these programmes during childhood. They found that school lunches influence children's health outcomes. They could decrease the probability of suffering any unhealthy condition (by 8% if children are exposed 9 years to this type of politics). Moreover, the levels of mortality, hospitalisations, disability, sick leave, etc. in these people are small and insignificant. However, the health benefits faded out unless they occurred at important stages for growth.

The most influential factors in their implementation in schools are macro politics, financial implications, school priorities, the responsibility of stakeholders, and environ-

mental and social characteristics (McIsaac et al., 2019). These are the reasons why it is so important to ensure synergy and coordination among different system levels.

Impact of the school environment on healthy eating habits in adolescents

According to Pulimeno et al. (2020), the school is the ideal environment for developing health education programmes. These programmes are aimed at acquiring both social and environmental skills and opportunities that influence students' healthy eating (Meiklejohn et al., 2016) while motivating them to make healthy lifestyle choices (Kaveh et al., 2018). Moreover, acquiring this nutrition education at school will enable adolescents to positively influence the dietary choices and practices of their family and friends (Liu et al., 2021).

Creating a good intervention programme is not easy. Hargreaves et al. (2022) proposed several recommendations in order to develop and implement policies and interventions related to nutrition. What is most important is to cut across sectors, it is essential that these policies and interventions are supported by education, health, and food systems, social protection and digital media.

Finally, as well as the programmes developed, the quality of the food offered in school canteens or vending machines is a determining factor in the prevention of obesity (Billich et al., 2021), which should include products that promote a balanced diet, as opposed to those products that are high in sugars, fats and salt (Wolfenden et al., 2017).

For all the above-mentioned reasons, it is very important to foster healthy eating among adolescents. High schools are a good option if we consider that students spend many hours there and are influenced by this environment (Nathan et al., 2011). Nutrition educational programmes must contribute to people's health (Oostindjer et al., 2017) and healthy eating patterns (Ismail et al., 2021). In this sense, the main objective of this paper is to investigate the effectiveness of several nutrition intervention programmes in adolescents aged 11-19 with respect to nutritional knowledge and behaviours.

Method

For the processes of searching and writing this article, we considered the statements of the Preferred Reporting Items for Systematic Review and Meta-Analyses 2020 (PRISMA statement; Page et al., 2021).

Literature search

The databases chosen for the search of studies were Scopus, PubMed, and Web of Science. They were screened from October 2022 to January 2023 with the objective of compiling the most complete list of studies possible. This search was undertaken by two of the authors independently, based on the agreement regarding the string search. We looked for relevant articles concerning nutrition programmes in high schools published in the last 10 years.

We used the following descriptors: ("PRE" AND "POST") AND ("dietary behaviour" OR "healthy eating behaviour" OR "healthy food" OR "healthy diet" OR "healthy eating" OR "healthy nutrition" OR "healthy habits") AND ("secondary education" OR "secondary school" OR "postprimary education" OR "high school" OR "bachillerato" OR "bachelor's degree" OR "baccalaureate" OR "bachelorship").

Inclusion and exclusion criteria

We have considered the following criteria during the selection process:

- Articles from scientific journals were accepted, whereas other types of studies such as gray literature were refused;
- Experimental or quasi-experimental articles were accepted. We refused articles without an intervention programme, a pre- and post-intervention, or an experimental group;
- Articles in English or Spanish language were included, whereas articles written in other languages were refused;
- Participants were required to be adolescents in high school, and studies with another population group or students from other educational stages as samples were refused.
- Nutrition intervention programmes in high schools were included, while articles whose variables were different from the food diet, such as postural control, were refused;
- Articles with open access were included, while articles to which we did not have complete access were refused.

Article selection and data extraction

Firstly, 110 articles were found by means of an automatic search. Articles published before 2013, repeated studies, and articles written in languages different from English or Spanish were removed, so we screened 50 articles in total. Then, applying the above-mentioned inclusion and exclusion criteria, 30 articles were selected for reading in detail. Finally, 19 articles were included in our systematic review. Figure 1 illustrates the selection process.

Two independent researchers extracted the following data from the 19 articles selected: authors' names, year of publication, sample size, country, instruments used, variables measured, description of intervention programmes, and main results. Then, the information was validated by a third author.

Study quality assessment

The authors discussed the descriptors and reached an agreement. Then, the literature search and article selection were carried out by two authors independently. Disagreements between the two reviewers were resolved by consensus. To calculate inter-reviewer reliability, the number of agreements was divided by the total number of disagreements. The result was then multiplied by 100 to obtain the percentage, resulting in 96%.

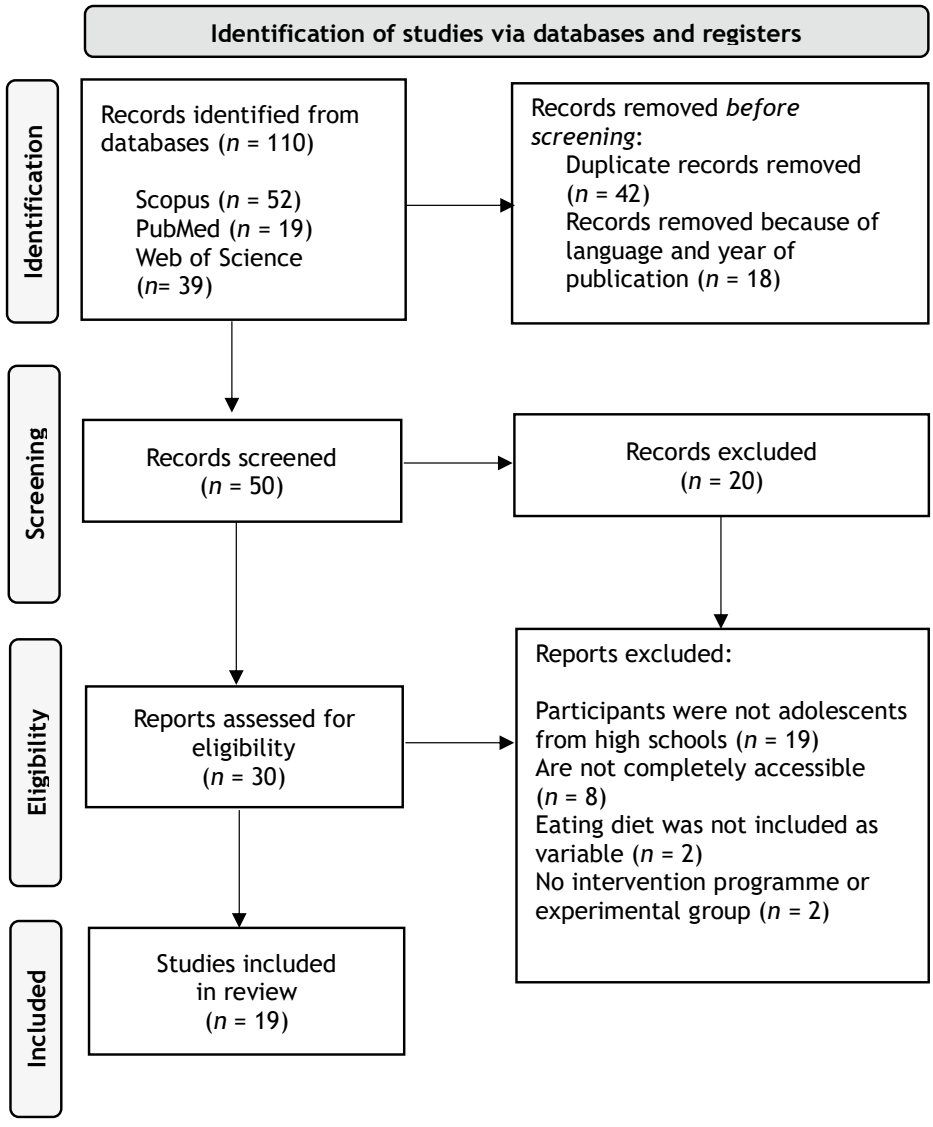

Figure 1. Flow diagram of the articles during the selection process

Results

Study characteristics

We analysed 19 articles in detail from which some data were extracted. Regarding the geographic location, there is a great variety. 6 articles were from Asia, 6 from America, 4 from Europe, 2 from Australia, and 1 from Africa. The country most studied was the United States (4 out of 19) followed by the Netherlands, India, and Australia (2 articles per country). The remainder of the countries were studied in only one article.

The age range was from 11 to 19 years old, predominately from 12 to 16 in more than 10 articles. We found articles in all of the years selected following the inclusion criteria except for 2019. Table 1 shows the characteristics of the articles analysed.

Intervention programmes

The effectiveness of an intervention programme depends on its aims, methods, and activities, among other factors (Dudley et al., 2015). For this reason, we found a wide range of different intervention programmes. All of the included articles have experimental and control groups in order to compare the differences among the groups. There are no repeated programmes; each article uses its own projects. On Table 2, the description of the different intervention programmes of the articles selected can be seen.

Table 1. Characteristics of the studies selected

Authors	Sample	Country	Instruments
Millar et al., 2013	12-16 years old (M = 14.3, SD = 0.63)	Australia	- Pre- and post-questionnaire - Interviews - Portable stadiometer - TANITA Body Composition Analyser for body weight.
Madden et al., 2013	12-16 years old (M = 14.3, SD = 0.63)	United Kingdom	- Pre- and post-questionnaire - Food data collection (FDC) - Computerised nutritional analysis package (FOODBASE, version 3.1 Standard Edition)
Rani et al., 2013	12-13 years old	India	- Pre- and post-questionnaire to evaluate the knowledge (15 items), attitude (9 items), and practices (5 items)
Jones et al., 2014	12-16 years old (M = 14.3, SD = 0.63)	United States	- Digital scales - Wall measurements of height - Weight Concerns Scale (WCS)
Yang et al., 2015	15-16 years old	China	- Cloud Diet Assessment System (CDAS) to evaluate students' daily intake of foods in terms of servings and nutrients - Harris-Benedict equation to evaluate the basal metabolic rate (BMR)
Kocken et al., 2015	12-14 years old (M = 13.6)	Netherlands	- Pre- and post-questionnaire about healthy eating knowledge (7 items), attitude (4 items), subjective norm (2 items), and behavioural control (2 items)
Barnes and Kristeller, 2016	12-19 years old (M = 16.2; SD = 1.2)	United States	- Stadiometer - Scale - Binge Eating Scale (BES, 16 items) - Three Factor Eating Questionnaire (TFEQ, 51 items) - Basic Assessment System for Children (BASC, 104 items).
Shahnazi et al., 2016	15-17 years old (M = 16.2, SD = 1.1)	Iran	- Pre- and post-questionnaire composite based on the BASNEF model, which included issues of belief, attitude, subjective norms, and enabling factors.
Dos Santos Ferreira Viero and De Farias, 2017	11-17 years old (M = 13.63; SD = 1.58)	Brazil	- Pre- and post-questionnaire
Pierce et al., 2017	12-13 years old	United States	- Interviews - ActiGraph Accelerometers to measure caloric expenditure - Child and Adolescent Mindfulness Measure Questionnaire - Perceived Stress Scale - Physical Activity Questionnaire for Adolescents - Youth Risk Behaviour Survey (YRBS) - Block Kids Food Screener Questionnaire
Noeret al., 2017	5-18 years old	Indonesia	- Healthy Eating Index Questionnaire - International Physical Activity Questionnaire (IPAQ) - Food Frequency Questionnaire (FFQ)
Saucedo-Molina et al., 2018	15-18 years old (M = 16.4)	Mexico	- The Brief Questionnaire on Disordered Eating Behaviours (BQDEB, 10 items) - International Physical Activity Questionnaire (IPAQ) - Drive for Muscularity Scale (DMS)
Meng et al., 2018	14-18 years old (M = 15.3, SD = 1.1)	United States	- Block Fat/Sugar/Fruit/ Vegetable Screener (Block-FSFV) to assess caloric intake - Fitbit-zip to assess physical activity - Nutrition and diet questionnaires
Shrewsbury et al., 2020	13-14 years old	Australia	- Pre- and post- questionnaire about Energy Balanced-Related Behaviours (EBRBs) and intentions to change EBRBs
Ibeanu et al., 2020	13-17 years old	Nigeria	- Questionnaire structured in 3 parts (part A evaluates the socio-demographic characteristics and lifestyle of participants; part B evaluates the participants' knowledge of nutrition; part C evaluates the consumption pattern of micronutrient-rich foods)

(*Continued*)

Authors	Sample	Country	Instruments
Huitink et al., 2021	12-14 years old	Netherlands	- Questionnaire with 29 questions measuring regular dietary behaviours during school hours, nutritional knowledge, and attitude towards healthy eating.
Rao et al., 2022	11-14 years old	India	- Pre- and post-questionnaire on whole grains
Majid et al., 2022	15 years old	Malaysia	- 3-day diastatic historical - Digital electronic weighing scale - Calibrated vertical stadiometer - Non-elastic measuring tape - Bioelectric impedance analyser - Questionnaire
Angeli et al., 2022	13-17 years old (M = 16.02, SD = 1.19)	Greece	- Attitudes towards healthy eating scale - Intention towards healthy eating scale - Subjective norm scale - Perceived behavioural control scale - Attitudes towards the application of the programme scale - Knowledge about healthy eating questionnaire - Exercise behaviour scale

Table 2. Description of intervention programmes

Authors	Description
Millar et al., 2013	Effectiveness of a Project called It's your move! (IYN). EG: using the Community Readiness to Change (RTC) tool to achieve changes in school environments to make them healthier and change the individual-level of knowledge, attitudes, beliefs, and behaviours regarding healthy eating and physical activity. CG: No intervention.
Madden et al., 2013	Effectiveness of a school kitchen-based intervention. EG: changing the school menu to reduce total and saturated fat and increase fruit and vegetable consumption. CG: no intervention.
Rani et al., 2013	Effectiveness of a nutrition education programme based on the Health Belief Model (HBM). EG: nutrition education was offered in the form of lectures and interactive discussions on topics such as eating disorders, the importance of nutritionally balanced food, the role of macro and micronutrients, or the health hazards of high-calorie foods. CG: no intervention.
Jones et al., 2014	Effectiveness of the Staying Fit programme. EG1 (students with weight problems who received the Weight Management (WM) intervention track) and EG2 (students with a normal weight who received the Healthy Habits (HH) intervention track): they conducted a food and refreshment log, a physical activity log, a weight log, were taught to be in tune with their internal appetite signals and were offered nutrition education lessons. CG: No intervention.
Yang et al., 2015	Effectiveness of a Game-based team learning (GBTL) programme enhanced with technology. EG 1: lecture-based learning activities with metacognitive feedback from the CDAS. EG2: social interdependence-based learning activities with the assistance of both CDAS and GBTL. CG: lecture-based learning on the weekly topic without the assistance of CDAS or GBTL.
Kocken et al., 2015	Effectiveness of a vending machines project. EG: educational component consisting of lessons on healthy food choices and an environmental-change component consisting of increasing the availability of lower-calorie foods in vending machines, labelling products as to give information on their type and energy value and reducing the prices of lower-calorie foods. CG: No intervention.
Barnes and Kristeller, 2016	Effectiveness of the MB-EAT programme. EG: 12 sessions based on the development of skills that are necessary to increase food awareness and food self-regulation and promote a change in physical activity. CG: No intervention
Shahnazi et al., 2016	Effectiveness of a programme based on the BASNEF model. EG: nutritional concepts on the importance of healthy eating habits, the prevalence of obesity, or the benefits of regular physical activity were taught through practical activities, video presentations, and displays posted on school notice boards. CG: No intervention.

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Authors	Description
Dos Santos Ferreira Viero and De Farias, 2017	Effectiveness of educational actions based on raising awareness of healthy lifestyle. EG: development of a health education action through an audiovisual exhibition, in which topics such as nutrition, physical education, and physiotherapy are discussed. CG: No intervention.
Pierce et al., 2017	Effectiveness of an educational intervention called Mission Thrive Summer (MTS). EG: they learned about sustainable agriculture and the food system in the farm environment. They also practiced physical activity and yoga. CG: No intervention.
Noer et al., 2017	Effectiveness of a programme based on peer nutrition counseling. EG: peer nutrition counseling sessions as an intervention for adolescent obesity problems. CG: only received leaflets.
Saucedo-Molina et al., 2018	Effectiveness of the Prevention of Unhealthy Eating Behaviours and Sedentary Lifestyles programme. EG: criticising and discussing body ideals, reflecting on dieting myths and realities, and acquiring knowledge about the nutrient content of foods. CG: No intervention.
Meng et al., 2018	Effectiveness of the WAVE-Ripples for Change: Obesity Prevention in Active Youth programme. EG: sports nutrition lessons, training, and experiential learning workshops with food tastings, cooking with fruit-based recipes, healthy food shopping, meal planning, and harvesting in the garden. CG: No intervention
Shrewsbury et al., 2020	Effectiveness of the Students As LifeStyle Activists (SALSA) program. EG: healthy lifestyle lessons taught by university students. CG: No intervention.
Ibeanu et al., 2020	Effectiveness of a nutrition education-based program. EG: experimental lessons providing educational aids with nutritional data, pictures of micronutrient-rich foods, and computer graphics. CG: No intervention.
Huitink et al., 2021	Effectiveness of a program called Healthy Supermarket Coach (HSC). EG: workshops were conducted by young supermarket employees, providing information on healthy foods and sugar-sweetened beverages (SSB), creating healthy lunches, and formulating action plans related to the purchase of healthy foods and SSB in the supermarket. CG: No intervention.
Rao et al., 2022	Effectiveness of the Eat Right School program. EG: nutrition education through games and visual presentations on the importance of consuming whole grains, their structure and composition, sources, their difference to refined grains, or the nutritional importance of rich sources of complex carbohydrates such as dietary fiber and B vitamins. CG: No intervention.
Majid et al., 2022	Effectiveness of the MyHeaART Beat program. EG 1: training in healthy food preparation only for food vendors. EG 2: training in healthy food preparation and creating a healthy environment. CG: No intervention.
Angeli et al., 2022	Effectiveness of a school-based educational program targeting healthy diet and exercise called DIEX. EG: activities on calculating Body Mass Index (BMI), food pyramid, food, labeling, ideal body campaigns, food, and physical activity diaries, organizing a food buffet, and organizing a conference of health experts. CG: No intervention.

Findings

Although different programmes have been carried out in each article, the findings can be explained with a close relationship. Students in experimental groups have improved their nutritional knowledge in general (Ibeanu et al., 2020; Rao et al., 2022), especially about diet and food groups (Rani et al., 2013), nutrients in commonly consumed food and their functions the importance of physical activity (Dos Santos & De Farias, 2017). The development of knowledge improves the eating behaviours of students (Angeli et al., 2022).

These types of programmes teach them to make healthier food choices (Huitink et al., 2021). In this sense, there was a decrease in the consumption of fat, saturated fat, carbohydrates, soft drinks, food from vending machines, junk food, and added sugar (Jones et al., 2014; Kocken et al., 2015; Madden et al., 2013; Meng et al., 2018; Noer et al., 2017; Pierce et al., 2017; Rani et al., 2013). On the contrary, healthy eating has increased. Shrewsbury et al. (2020) found a daily increase in fruit intake of 5.2%. Other authors also found this increase not only in fruit but also in vegetables (Jones et al., 2014; Madden et al., 2013; Pierce et al., 2017) and meat and protein (Yang et al., 2015). Although Meng et al. (2018) found no significant change in fruit and vegetable intake, and Kocken et al. (2015) found no effect on the intention of drinking light drinks or water and eating low-calorie sweets, cakes, or snacks.

Physical activity has also increased following the intervention programmes. We found significant differences in almost all of the studies selected, except for Noer et al. (2017) who affirmed that there were no significant differences between pre and post-tests.

All these benefits of intervention programmes make the prevalence of weight problems and obesity decrease (Millar et al., 2013), establishing significant differences between groups (experimental and control groups) in the Body Mass Index (Kocken et al., 2015). Moreover, Saucedo-Molina et al. (2018) affirmed that disordered eating behaviours decreased in girls over time. Regarding the differences between genders, we also found that girls ate significantly more fruit than boys (Madden et al., 2013) and girls have greater aptitude and awareness of different aspects of whole grains (Rao et al., 2022).

Finally, intervention programmes change the attitudes of students in EG towards a healthy diet and cause changes in the intentions for the future of these people (Rani et al., 2013; Shrewsbury et al., 2020). However, Angeli et al. (2022) found no significant differences in students' attitudes towards healthy eating, healthy eating intentions, perception of their control of healthy eating behaviour, and exercise behaviour.

Table 3. Findings of each article

Authors	Results
Millar et al., 2013	- EG recorded a statistically significant decrease in the prevalence of overweight/obesity.
Madden et al., 2013	- After the intervention, the mean intake of energy and the mean proportion of energy provided by fat and saturated fat consumed by girls and boys were significantly lower than before ($p < 0.05$). - The proportion of energy from carbohydrates significantly increased after the intervention. - A significant increase in consumption was observed after the intervention for total fruit and vegetable intake, although the total amount consumed remained low. - Girls ate significantly more fruit than boys (13.6 vs. 5.9, $p < 0.05$).
Rani et al., 2013	- There was a significant improvement in the dietary knowledge of the students after the programme (from 37% to 67%, $p < 0.001$). - There were significant improvements in the knowledge of sources and value of food groups (from 29% to 57%, $p < 0.001$), required servings of fruits, vegetables, and dairy products per day (from 42% to 81%, $p < 0.001$), the importance of a balanced diet (from 35% to 62%, $p < 0.001$), and the health hazards of eating high calorie or junk foods (from 38% to 54%, $p < 0.01$). - The proportion of students showing a positive attitude towards a healthy diet significantly increased from 18% to 40 % ($p < 0.001$) after the programme. - The proportion of students consuming soft drinks daily was significantly reduced from 20% to 10% ($p < 0.01$).
Jones et al., 2014	- The BMI percentile for participants in the EG2 was stable ($SD = 6.53$, $p = .791$). However, there was a significant decrease in the BMI percentile for participants in the EG1 ($SD = 1.49$, $p = .001$). - Significant increase in consumption of two or more pieces of fruit for participants in the EG2 ($p < .001$) and for participants in the EG1 ($p < .001$). - Significant increase in consumption of two or more vegetables for participants in the EG2 ($p < .001$), but it was not significant for participants in the EG1 ($p = .752$). - There was a significant increase in the consumption of soft drinks at least once a day for participants in the EG2 ($p < .001$) and a significant decrease for participants in the EG1 ($p = .002$). - There was a significant decrease in physical activity for participants in the EG2 ($p < .001$) and a significant increase for participants in the EG1 ($p < .001$). - The intervention was effective in reducing weight and shape concerns among participants with elevated eating disorders risk.
Yang et al., 2015	- There was an increase in dairy consumption ($M = 63$, $SD = 111$) for EG2, although at the post-test and an average of 63% still did not meet the recommended daily intake. - There was an increase in the consumption of meat and protein ($M = 93$, $SD = 25$), vegetables ($M = 102$, $SD = 62$), and fruit ($M = 65$, $SD = 33$) for EG2, with these variables being closer to the recommended daily intake levels. - There were positive improvements for EG2 in terms of calories ($M = 96$, $SD = 16$) and dietary fiber ($M = 68$), with higher intakes in the latter weeks of the intervention.
Kocken et al., 2015	- At post-test, students in the EG had more knowledge of nutrition, energy intake, and portion size than those in the CG. - No effect was found on the behavioural determinants of attitude, social norm, perceived behavioural control, and intention with respect to drinking light drinks or water and eating low-calorie sweets, cakes, or snacks. - There was a decrease in EG in self-reported purchases of soft drinks and extra foods from school vending machines. - Students in the EG reported bringing drinks and extra foods from home less often, while the CG brought drinks from home more frequently. - The difference in BMI between EG and CG is significant (43% vs. 56%, $p < 0.05$).

(*Continued*)

Authors	Results
Barnes and Kristeller, 2016	- Increase in the number of servings per week of low-calorie foods (7.7 vs. -0.5, $p < .02$), food with no saturated fats (5.1 vs. -0.4, $p < .10$), and low unsaturated fats (4.6 vs. -2.7, $p < .02$). - EG increased days/week of aerobic exercise (1.4 vs. -0.5, $p < .05$). - EG slightly decreased in weight 0.3 pounds compared to an increase of 0.4 pounds in the CG, although BMI stayed the same for both groups. - The Binge Eating Severity (BES) negatively correlated with attitude towards school ($p = 0.04$), but not with other variables such as anxiety ($p = 0.4$), depression ($p = 1.0$), interpersonal relations ($p = 0.2$), and self-esteem ($p = 0.4$) - BES total scores were similar between boys and girls (boys: 13.4 ± 10.9, girls: 12.8 ± 9.6, $p = 0.9$). - In boys, BES negatively correlated with self-esteem ($p = 0.02$), and positively correlated with interpersonal relations ($p = 0.04$). In girls, binge eating severity negatively correlated with sensation seeking ($p = 0.01$).
Shahnazi et al., 2016	- There was a significant positive correlation between attitude and subjective norms ($r = 0.48$, $p < 0.001$) and intention for controlling healthy eating ($r = 0.42$, $p < 0.001$). - There was a significant positive correlation between subjective norms with enabling factors ($r = 0.53$, $p < 0.001$) and self-administration ($r = 0.62$, $p < 0.001$). - Intention and self-administrated physical activity increased significantly in the EG.
Dos Santos Ferreira Viero and De Farias, 2017	- There was a significant increase in knowledge about unhealthy eating issues after the intervention (pre-test= 3.86 ± 1.39, post-test= 4.64 ± 1.67, $p < 0.05$). - There was a significant improvement in knowledge related to physical activity after the intervention (pre-test= 4.52 ± 1.69, post-test= 5.10 ± 1.46).
Pierce et al., 2017	- High levels of physical activity and energy expenditure were observed among participants during the programme. - There were numerous positive changes in healthy eating habits after the intervention. There were increases in the number of days in the last week that participants ate fruit and vegetables. Also, there were decreases in the number of days participants ate junk food. - Participants experienced statistically significant improvements in physical activity ($p = 0.008$) after the intervention. - No significant changes were detected in participants' stress or mindfulness ($p = 0.07$).
Noer et al., 2017	- Both groups had a high dietary intake of energy, fat and low in fiber, and less physical activity before the intervention. - There was a difference between energy, fiber, and fat intake before and after the intervention in the EG ($p < 0.05$). - The decrease in energy and fat intake is greater in the EG than in the CG ($p = 0.001$). - The increase in fiber intake is greater in the EG than in the CG ($p = 0.001$). - The average change in physical activity before and after the intervention showed no significant differences ($p > 0.05$).
Saucedo-Molina et al., 2018	- Sex/time interaction showed significant differences because in girls the mean DEB score significantly decreased over time. - DMS score in boys decreased over time. - Physical activity frequency and duration showed a significant increase in the total sample over time.
Meng et al., 2018	- There was a significant decrease in added sugar (-12g/day) and saturated fats (2.7g/day). Although there was no change in the intake of sugar-sweetened beverages. - There was no significant change in fruit and vegetable intake ($p = 0.89$). - During the intervention, both groups had significantly higher physical activity in-season (9937 steps/day) compared to out-of-season (8117 steps/day).
Shrewsbury et al., 2020	- There was a 5.2% increase in the proportion of students who reported eating ≥ 2 servings of fruit daily ($p < .001$). - There was a 4.3% increase in students drinking <1 cup of sugar-sweetened beverages daily ($p < .001$). - There were significant changes in the proportion of students intending over the next month to eat breakfast daily ($p = .05$), to eat ≥ 2 servings of fruit ($p < .001$), to eat ≥ 5 servings of vegetables daily ($p < .01$) and to limit recreational screen time on school days to ≤ 2 hours/day ($p < .001$).
Ibeanu et al., 2020	- There was an increase in knowledge of general nutrition after the intervention (from 32.34% to 69.33%). - There was an increase in knowledge of the main nutrients of some commonly consumed food after the intervention (from 42.35% to 68.85%). - There was an increase in knowledge of the functions of micronutrients after the intervention (from 7.25% to 24.23%). - There was an increase in knowledge of micronutrient deficiencies after the intervention (from 20.48% to 54.64%). - Overall, the nutrition education intervention improved healthy food choices among adolescents and reduced their preferences of foods that inhibit nutrient absorption.

(*Continued*)

Authors	Results
Huitink et al., 2021	- Improved the nutritional knowledge of the students who participated in the workshops (pre-test: *M* = 7.71, *SD* = 1.72 vs. post-test: *M* = 8.24, *SD* = 1.76, $p \leq .001$). - Improved attitudes towards healthy eating among students who participated in the workshops (pre-test: *M* = 0.81, *SD* = 0.56 vs. post-test: *M* = 0.94, *SD* = 0.58, $p \leq .001$). - Students evaluated the HSC intervention positively (7.43 points out of 10). - Students reported that they enjoyed the workshops (*M* = 0.66, *SD* = 1.08). - Students reported that the workshops had taught them to make healthier food choices in the supermarket (*M* = 0.64, *SD* = 1.12). - Students reported that they intended to implement the lessons that they had learned (*M* = 0.43, *SD* = 1.16).
Rao et al., 2022	- There was a significant increase in knowledge about different aspects of whole grains ($p \leq 0.05$), and in knowledge and awareness of different examples of whole grains and their nutritional composition ($p \leq 0.05$). - There was an increase in awareness of the importance and processing of whole grains. As well as when they were asked about the colour of bread as an indicator of wholegrain ($p \leq 0.05$). - Greater aptitude and awareness of different aspects of whole grains was observed among female students compared to male students ($p < 0.05$). - There was a significant increase in iron deficiency disorders after the intervention. Knowledge about the importance and role of iron increased from 27.30% to 59.50%, iron deficiency anemia from 34.03% to 59.85%, sources of iron from 25.20% to 51.70%, and iron absorption from 36 % to 61.2%.
Majid et al., 2022	- All groups the two experimental groups and the control group showed a significant difference in weight, height, energy, and carbohydrate intake. - There were statistically significant differences in percentage of body fat and fat intake in EG1. - Waist circumference had statistically significant differences pre- and post-intervention for EG2. - Overall, none of the variables studied showed statistically significant differences between EG 1, EG 2, and CG.
Angeli et al., 2022	- Improvement of students' knowledge about healthy eating after the application of the programme ($p < 0.01$). - Improvement of students' nutritional behaviour after the application of the programme ($p < 0.001$). - Higher scores on their attitudes towards the application of the programme in the post-test ($p < 0.05$). - There were no significant differences in students' attitudes towards healthy eating ($p = 0.134$), in students' healthy eating intentions ($p = 0.462$), in students' perception of their control of healthy eating behaviour ($p = 0.618$), and in students' exercise behaviour ($p = 0.812$).

Discussion

The purpose of this systematic review was to examine the effectiveness of several intervention programmes in promoting healthy nutrition and physical activity in high schools. In general, the application of these types of programmes was satisfactory and improved knowledge and behaviours.

Firstly, our results showed that health education programmes have a positive impact on students' knowledge. This is in line with the Elias et al. (2018) study which affirms that nutrition knowledge was developed among physically active people. We also found previous studies along this line. Little et al. (2002) found a significant increase in nutrition knowledge in a low-income community, especially among girls. In addition, Arlinghaus and Johnston (2017) affirm that education on a specific topic increases personal skills and awareness.

Secondly, it is also important to highlight that there is a relation between knowledge and nutrition choices, as we can verify in our results. This is consistent with Koca and Arkan (2020) who say that knowledge affects students' habits. However, there are other factors implicated in these choices (Partida et al., 2018). Students are influenced by gender (Guttersrud & Sverre, 2015) and their environments (Worsley, 2002): family customs, what is socially accepted as cool, and friends' habits. The differences between genders found in terms of eating fruit (Madden et al., 2013) and having a greater aptitude and awareness (Del Rio et al., 2022) are supported by another study that affirms that girls give more importance to health than boys (Lee et al., 2019).

In any case, investigating the relationship between nutritional knowledge and the quality of dietary intake can help adopt effective strategies (Joulaei et al., 2018). Regarding the quality of diets, we found an increase in the consumption of fruit and vegetables (FV) (Jones et al., 2014; Pierce et al., 2017; Yang et al., 2015) and a decrease in fat and saturated fat food (Madden et al., 2013; Meng et al., 2018; Noer et al., 2019), soft drinks (Jones et al., 2014; Rani et al., 2013) and junk food (Piece et al., 2017). The results regarding fruit and vegetable intake are affirmed by Foley et al. (2017) who showed that their sample got the recommendation for its consumption. Years ago, Lytle et al. (2004), Siega-Riz et al. (2011), and Wilson et al. (2012) also showed an improvement in short-term FV intake after intervention programmes. Moreover, Huitink et al. (2021) affirm that the programmes teach students to make healthier food choices at the supermarket. In this sense, nutrition programmes inside the school could be enriched with supermarket tours. Nikolaus et al. (2016) demonstrated that these tours increase knowledge, skills, and positive attitudes. On the other hand, it was corroborated that the school canteen influences the students' choices (Wolfenden et al., 2017) because they perceived that healthy food is sold in the canteen (Mohammadi et al., 2020). Many students purport buying unhealthy food or drinks during school hours (Rid-

der et al., 2017), for this reason, canteens and food shops around high schools should encourage healthy food choices (Timmermans et al., 2018).

Thirdly, we found that in almost all of the articles it was affirmed that physical activity increased following the intervention programmes. Saucedo-Molina et al. (2018) found a significant and positive effect in the short-term, but these changes were not maintained in the long-term. In the follow-up, scores are better than in the pre-test but worse than in the post-test. These results are in accordance with previous research which affirmed that short-term changes fail at the follow-up (Stice et al., 2011). Moreover, Jones et al. (2014) establish differences between overweight people who increase their physical activity and normal-weight people. The impact of physical activity on the overweight people group is very positive even though it was an Internet-based intervention. In this sense, these types of interventions have good results in sedentary people (Carr et al., 2008).

As we said before, the prevalence of weight problems and obesity decreased (Millar et al., 2013), establishing significant differences between groups (experimental and control groups) in the Body Mass Index (Kocken et al., 2015). BMI is an indicator of weight problems and obesity (World Health Organisation, s.f.b). Our results are supported by D'Amato-Kubiet (2013). He found that the BMI was reduced when nutritional knowledge improved among young people.

Finally, for these findings that were not statically significant, Álvarez et al. (2019) indicate that students sometimes need more time to assimilate specific information. What is more, knowledge alone is not enough to change people's behaviours (Vaitkeviciute et al., 2015). Conceivably, it would be better if the programmes had included educational and practical components. Several studies have shown that policies for healthy school food, provision of fruit and vegetables, and canteen-based healthy food are essential (Nik et al., 2018). Therefore, we cannot forget that a strong intervention should be carried out (Downs & Demmler, 2020).

Conclusion

To conclude, nutrition intervention programmes at high schools have a great impact on nutritional knowledge and behaviours. The main goal of this systematic review was to investigate the effectiveness of several nutritional programmes in the high school stage. As we were able to corroborate, students improved their knowledge in this area and increased healthy intake. In this sense, Schlechter et al. (2016) affirmed that school environments and families are two essential factors in modifying adolescents' dietary behaviours.

We followed the PRISMA methodology which is recommended in social science research. It stands out for its transparency and openness to comments. However, we encountered a few limitations: publication year and type of publication. Our objective was that this systematic review would be current and relevant. For this reason, we refused articles that were not published in scientific journals as well as articles published before 2013.

Educational implications can be drawn from this article, as management teams at schools can verify the advantages of each type of programme and choose the best option to improve nutritional knowledge and attitudes among their students. Future work could emphasise a cross-programme that includes families and schools having the same objective, the health of adolescents.

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