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Review

# Effectiveness of school-based interventions in Europe for promoting healthy lifestyle behaviors in children

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**Abstract:** The objective of this review was to summarize existing literature on the effectiveness of school-based interventions, implemented in Europe, under the aim of promoting healthy lifestyle behaviors in children (6 -10 years old). A search of PubMed, Scopus, EFSA and Google Scholar databases was performed for studies published from January 2016 until June 2022. Specific search terms and exclusion criteria were used. Based on the results, diet and physical activity interventions had favorable effects in a series of health outcomes, including anthropometric parameters, biomarkers, eating behavior and self-efficacy. Diet-only interventions had a positive impact specifically on eating habits, mostly on water consumption. Most successful interventions lasted for 1 school year and they were characterized by parents' participation in training and teachers' training.

**Keywords:** school-based interventions; healthy lifestyle behaviors; children; obesity prevention

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## 1. Introduction

Childhood is one of the critical periods for good health and development in human life. During childhood, the physiological needs for nutrients increase and the adoption and maintenance of high quality eating habits is particularly important [1]. A healthful diet during childhood promotes growth and cognitive development of the child and may contribute to the prevention of chronic disease in later life [2, 3]. Similarly, regular physical activity is associated with physiological and mental health benefits, including a low risk of adiposity, improved fitness and optimal cardiometabolic health [4, 5]. Evidence suggests that both eating and physical activity habits adopted early in life track to some extent into adulthood [6, 7]. It is therefore important to establish healthy lifestyle behaviors as early as possible during lifetime. However, dietary consumption surveys show that most European children do not meet these guidelines [8, 9] and a great proportion of children fail to meet

current guidelines of 60 min of moderate to vigorous physical activity per day [10].

Recent figures also show alarming and increasing numbers of children with overweight or obesity in Europe. Childhood obesity is associated with several short-term physical health consequences, such as adverse blood lipid profile, altered glucose metabolism, obstructive sleep apnea, as well as long-term effects, such as higher risk for hypertension, diabetes mellitus, cardiovascular disease, gallbladder disease and osteoarthritis in adulthood [11-14]. The presence of overweight and obesity during childhood have also been linked with psychosocial adverse consequences, such as poor self-image, low self-esteem, higher risk for eating disorders and poor quality of life [15]. The increasing prevalence of childhood obesity can be linked to social and lifestyle changes in Europe occurring over the last three decades with the development of unhealthy eating habits (characterized by high intake of unhealthy lipids and added sugars, as well as by low consumption of complex carbohydrates and fiber) and sedentary way of living (high number of hour spent on screen and low engagement in lifestyle physical activities) [11]. To date, many programs have been developed to promote a healthy lifestyle and prevent obesity in children. The vast majority of these programs use schools as the optimal setting for the implementation of interventions targeting school-aged children [16].

Schools are a crucial social environment for children and many attempts have been made to utilize this environment to promote healthful behaviors in youth, including healthful eating and physical activity habits [17-19]. School-based interventions have the potential to reach almost 100% of children of diverse ethnic and socio-economic groups. Other influencing factors for eating behaviors at the school environment are the availability of food and beverages apart from the meals served in many countries (e.g., foods provided in vending machines and school stores) and the provision of nutrition education classes. Additionally, schools can promote physical activity as children spend a large proportion of their waking time, apart from the fact that structured physical activity and sports education are a mandatory part of the school curriculum, so that all children have to participate in [20]. Thus, schools represent an ideal setting to promote and provide both healthy nutrition and physical activity education [17, 21].

Previous reviews of school-based interventions have demonstrated a variety of different intervention approaches, including nutrition knowledge classes, increased availability of healthy foods, food programs providing free foods, environmental changes, parental involvement, and teachers' training. Although several reviews so far have yielded information regarding different intervention approaches, delivery modes, and outcome measurements, no one has focused on describing the characteristics of effective school-based interventions and therefore conclusions regarding successful components of those programs are difficult to be drawn. The identification of the most common characteristics of successful interventions will provide valuable information when designing future programs. Additionally, no recent (in the last 10 years) review has been published so far that includes the latest interventions implemented in the European countries. Given that the socioeconomic context and school systems are different in the most European countries compared to the U.S. or to other countries in the American continent or in Asia, and this is also true for the physical activity and the eating environment. Therefore, reviews focusing on school interventions that share common geoenvironmental and cultural background are necessary as already pointed out in past reviews published in early 2010's [21, 22].

Thus, the aim of the present review is to review the most recently launched school-based interventions for promoting healthy lifestyle behaviors in Europe with a focus on the best practices the successful interventions have so far implemented in order to identify the most common ones.

## 2. Methods

### Strategy Used

A search of PubMed, Scopus, EFSA and Google Scholar databases was performed for studies published from January 2016 until June 2022. Search terms were ‘school based intervention’, ‘diet’, ‘nutrition’, ‘nutritional program’, ‘food education’, ‘hydration’, ‘water consumption’, ‘physical activity’ and ‘exercise’ used individually and in combination (‘school based interventions and diet or nutrition program or food education’, ‘school based interventions and physical activity’, ‘school based interventions and water consumption or hydration’).

The sampling frame for this review was effective school-based interventions in food education towards children. In addition, studies were included if they: (i) were investigated the effectiveness of a school-based intervention targeting PA behavior, and/or nutrition behavior (NB); (ii) were clinical trials (iii) targeted children aged 6 to 10 years; (iv) conducted in Europe; (v) were written in English language.

Observational studies or review and family-based interventions were excluded.

### Studies Retrieved

Figure 1 summarizes review article selection. The initial databases search yielded 245 publications. After screening titles and/or abstracts, the total number was reduced to 103. After careful review, 93 publications were excluded because they did not meet one or more of the inclusion criteria. Almost all of the excluded publications were studies that were not conducted in Europe or target preschool children or adolescents.

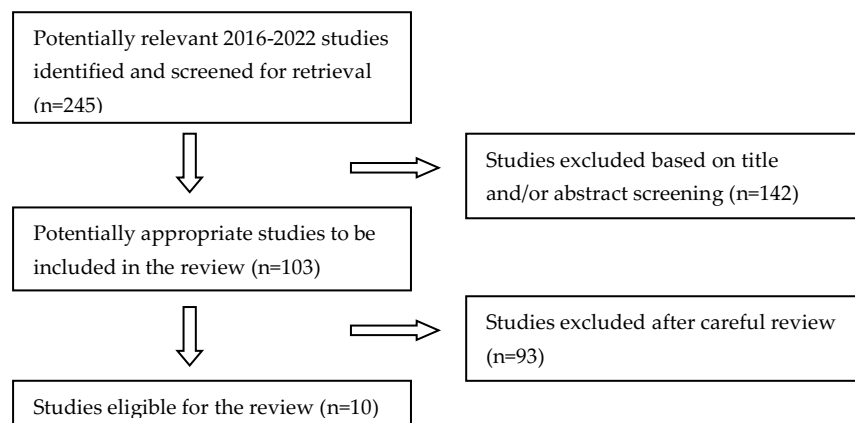


Figure 1. Flow diagram: school-based interventions

## 3. Results

The nine studies included in the current analysis have been presented in Table 1, namely their target population, their design, duration, and type of intervention (diet only or diet and physical activity). The interventions in the Table have been presented

based on their number of participants on a descending order. Publications referred to the same project were grouped together. Interventions' duration ranged from 5 weeks to 2 years. Of the 9 included studies, 5 examined interventions involving diet and physical activity and the other 4 examined diet only.

### 3.1 Diet only interventions

Most of the diet only interventions examined the potential association of a series of school-based interventions that included and targeted only water intake (2 studies) [23, 24] or water intake and nutrition education (1 study) [25] with relevant environmental changes in order to increase children's water consumption and decrease their sugar-sweetened beverages consumption (Table 2).

**Table 1. General characteristics of the included studies**

Program name	Country	Study design	Duration	Population group	Parents' involvement	Teachers' training	Theoretical model			Authors
							Social Cognitive Theory	Ecological Model	Health promotion model	
<i>Diet only</i>										
<i>Diatrofi</i>	<i>Greece</i>	RCT	1 school year	N= 6288, elementary and secondary schools	X					Dalma et al., 2018 [26]
<i>'H2NOE Water Schools</i>	<i>Austria</i>	non-randomized controlled cluster trial	1 school year	N = 1148, 8 years old	X	X			X	Griebler et al., 2021 [23]
<i>HKCC</i>	<i>United Kingdom</i>	non-randomized CT	1 school year	N =931, 8-14 years old	X			X	X	Irwin et al., 2019 [24]
<i>ACTION</i>	<i>Austria</i>	RCT	5 weeks	N = 344, 5th grade		X			X	Winzer et al., 2021 [25]
<i>Diet &amp; PA</i>										
<i>POIBA</i>	<i>Spain</i>	multicomponent and multilevel RCT	1 school year	N= 3073, 9-10 years old	X	X				Ariza et al., 2019 [27]
				N=1653, 9-10 years old	X	X				Sánchez-Martínez et al., 2021 [28]

-		RCT	6 weeks	N= 1609, 9-15 years old						Altay et al., 2020 [29]
<i>Health Promotion Intervention to Improve Diet Quality in Children</i>	<i>Portugal</i>	RCT	6 months teachers' training/ 5 months implementation	N=294, 6-12 years old		X	X		X	Rosário et al., 2017 [30]
<i>HHP</i>	<i>Spain</i>	RCT	8 months	N= 158, 5th or 6th grade	X	X				Pablos et al., 2018 [31]
<i>RCT: Randomized clinical trial, PA: Physical activity</i> <i>Project Spraoi Ireland</i>		RCT	2 years	N= 101, 6 & 10 years old	X				X	Merrotsy et al., 2019 [32]

**Table 2. Components of intervention programs**

Program name	Intervention	Outcome measures			Authors
		Anthropometrics	Nutrition behavior	Other	
<i>Diet only</i>					
<i>Diatrofi</i>	Intervention A: daily lunch bag Intervention B: food-voucher		↑ positive food preferences at school	↑Self-organization	Dalma et al., 2018 [26]
<i>H<sub>2</sub>NOE Water Schools</i>	Fee refillable water bottle and workshops		↑ Water consumption		Griebler et al., 2021 [23]
<i>HKCC</i>	Education programs about Water and SSBs consumption and Water bottle filling stations		↑ Water consumption ↓ SSBs consumption	↑ nutrition knowledge	Irwin et al., 2019 [24]
<i>ACTION</i>	Diet and Hydration sessions		↓ Free sugar intake		Winzer et al., 2021 [25]
<i>Diet &amp; PA</i>					
<i>POIBA</i>	Evaluation of Body Weight, Diet & PA sessions	↓ Incidence of obesity			Ariza et al., 2019 [27]
	Family workshops Subsidized fees for extracurricular sports for some families	↓ Incidence of obesity			Sánchez-Martínez et al., 2021 [28]
-	Evaluation of Body Weight, Healthy lifestyle sessions, workshops and booklets		↑ Breakfast consumption	↑ Self-efficacy	Altay et al., 2020 [29]



<i>Health Promotion Intervention to Improve Diet Quality in Children</i>	Interactive Overweight and Obesity prevention, Diet, PA, Hydration and Cooking sessions Sessions delivered by trained teachers who took the same sessions		↑Vegetables adequacy ↑sodium moderation		Rosário et al., 2017 [30]
<i>HHP</i>	PA sessions and activities Interactive Healthy habits sessions Sessions delivered by trained teachers Worksheets completion about healthy habits Workshops for family and teachers	↑ prevalence for BMI according to level	↑ proper breakfast consumption ↑ better diet quality	↓ Glucose ↓ TAG ↓ BP ↑ VO <sub>2max</sub>	Pablos et al., 2018 [31]
<i>Project Spraoi</i>	PA and nutrition sessions and PA classes	↓ Waist to height ratio (only 10 years old children)	↑ Fiber intake (only 6 years old boys)	↓ Systolic & diastolic BP (only 10 years old children)	Merrotsy et al., 2019 [32]

BMI: Body mass index, BP: Blood pressure, PA: Physical activity, SSBs: Sugar-sweetened beverages, TAG: Triacylglycerides, VO<sub>2max</sub> : Maximal oxygen uptake

These programs exhibited a good potential for public health impact, as they documented improvements in dietary behaviors, such as water consumption, free sugar intake and upgrades in nutrition-related knowledge. Three interventions were based on the health promotion model [23-25], and one of them was also based on the ecological model [24]. In addition, mixed modes of intervention delivery were found: one study involved teachers' training and participation of children's parents [23], another study involved teachers' training [25] and in the third intervention only children's parents participated and there was no teachers' training [24] (Table 1)

The DIATROFI program was conducted by directly comparing two different intervention approaches: food-voucher approach or free daily meal distribution and found that the meal distribution intervention was considered more effective than the food voucher one, not only because of its pedagogical benefits, but most importantly because it appeared to improve dietary habits, alleviate food insecurity and break stereotypes for parents and children through universal student participation [26] (Table 2). In DIATROFI intervention, children's parents participated without teachers' training (Table 1).

### 3.2 Diet and Physical Activity interventions

Among diet and physical activity interventions, 2 involved teachers' training and participation of children's parents [27, 28, 31], 1 teachers' training [30] and 1 participation of children's parents [32]. Teachers' training was conducted through workshops concerning healthy habits for school children and/or through teaching material (re-printed posters for drinking rules or pre-prints to record the children's fluid intake). In one program teachers delivered specific education contents (overweight and obesity prevention, concepts of food, nutrition, and dietary guidelines for children and families, hydration and the importance of water, strategies to encourage fruit and vegetable consumption and to reduce low-nutrition, energy-dense foods, appropriate physical activity levels and strategies to reduce screen time, healthy cooking activities) and then they further developed creative and engaging classroom activities on the addressed topics. Themed games and modified sports were performed under the following thematic areas: fun, inclusion and cooperation and safety.

The intervention program of one study was based on the health promotion model and the social cognitive theory [30] and the intervention program of another one was based only on the social cognitive theory [31]. Both interventions improved children's dietary behavior and the intervention lasted for 2 years had beneficial effects on anthropometric measurements and biomarkers even though this result concerned children of a specific age (10 years of age).

Three studies had a benefit on anthropometric measurements [27, 28, 31, 32]. Specifically, 1 study showed a reduction in the incidence of obesity [27, 28], another one showed an increase in the % of children of healthy body weight [31] and one found a reduction in the waist-to-height ratio but this reduction was recorded only in 10-year-old children [32]. Furthermore, 2 studies had a beneficial effect on biomarkers and blood pressure (BP) [31, 32]. In specific, blood glucose

and triacylglycerides (TAG) concentrations were reduced following intervention [31]. Four studies found favorable change for at least one dietary behavior outcome [29–32]. These behaviors include regular breakfast consumption [29, 31], adequate vegetables consumption, moderation in sodium intake [30] and adequate fiber intake (shown only in 6-year-old boys) [32] and better diet quality [31]. Finally, one study showed improvement in self-efficacy of children [29].

#### 4. Discussion

The present review aimed to critically summarize available evidence on successful school-based interventions for promoting healthy lifestyle behaviors in Europe. The review specifically focused on the findings of effective school-based interventions that exhibited changes in any kind of health outcomes. We observed that diet and physical activity interventions had favorable results in a series of health outcomes, such as anthropometric measurements, biomarkers, eating behavior and self-efficacy; as expected diet only interventions had a positive impact only on specific eating behaviors. It was also noticed that the majority of successful interventions included participation of children's parents and/or teachers' training and lasted for 1 school year. Furthermore, half of the included studies were based on a theoretical model.

The results of previous works that included studies from outside Europe are consistent with our findings. Thus, a review, conducted in 2014 had suggested that interventions toward healthy eating habits and physical activity at school could be a strategy in the prevention of obesity [33]. The aforementioned review included interventions delivered in primary schools (children aged until 12 years) and examined the impact of these interventions on outcomes in terms of BMI or any anthropometric measures (weight, waist circumference or other indicators of adiposity); 15/35 studies were performed in Europe.

Regarding the mode of delivery, it is widely accepted that parents play a central role in shaping children's eating patterns and consequently it is advocated that interventions, aiming at improving children's lifestyle behaviors, need to address the family [34, 35]. In the studies included in the present review, children's parents were involved in different ways: they were recipients of information material about healthy food habits (lunchbox ideas, hydration, tasting sessions and education sessions on high-sugar beverages and takeaways), they participated in family workshops on food and physical activity in school, they supported their children in their tasks for the program (assisting children's self-monitoring regarding eating and drinking habits), they were beneficiaries of food vouchers. Moreover, parents participated in focus groups about perceptions regarding the program, triggers and barriers of participation, attitudes towards the program and suggestions for improving program's implementation. Two previous reviews had shown that school-based interventions with parental involvement had the potential to improve children's weight status, physical activity, and sedentary behavior [36, 37]. On the other hand, according to the results of a systematic review conducted in 2012 on combined community or school and home-based, obesity-prevention interventions, only 7 out of the 15 studies produced beneficial changes in lifestyle outcomes, namely eating behavior, physical activity levels, sedentary

behavior, or weight status and other health risk factors [38]. Nevertheless, it should be added that this review did not focus on school-based interventions as it included community-based ones too. Another possible explanation for the inconsistencies between our findings and the 2012 review is the different age groups investigated. We examined interventions performed in primary school children while the review to be discussed included interventions performed in children aged from 1 to 18 years.

It has been found that teachers' training is an effective strategy at improving physical activity of students [40]. Even though all school-based interventions described in the current review were successful, some of them had impact on more outcomes than others. Interventions that aimed to promote both nutrition and physical activity led to improvements in a series of health outcomes [31, 32]. In addition to this, parental involvement and teachers' training were found to be the most common components of successful school-based interventions.

Previous reviews had pointed out the heterogeneity of the studies they included in terms of design. We noticed that the majority of successful interventions had a duration of 1 school year. Additionally, a theoretical model was found in research methods in half of the studies in this review. This is consistent with a previous review conducted in 2006, addressing the important role of social cognitive theory when designing interventions for preventing and treating childhood obesity. Specifically, this review aimed to describe theoretical and methodological characteristics of effective school-based interventions resulting in a significant decrease in BMI or weight in children aged 4 to 14 years (2/10 studies were European). We found that the inclusion of a theoretical model in the intervention programs led to the improvement of other parameters too mostly in dietary behavior.

In this work we focused on successful interventions under the aim of identifying their common components. We included only controlled trials in the review, as they are considered to be the gold standard for drawing conclusions [41]. Studies without published outcomes were excluded as it was not possible to evaluate their efficacy. We also evaluated the interventions' effectiveness over a series of health outcomes, and we did not focus solely on anthropometry and physical activity measures.

The limitations of this work should also be acknowledged. This is not a systematic review, due to the limited number of interventions found. We included only studies conducted in European countries, published in three databases. While these databases are quite extensive, yet they do not include studies published in other than English European languages. Therefore, publication bias cannot be excluded. However, to counterbalance this limitation, grey literature was also searched. Despite these limitations, the review provides a broad up to date overview of all successful practices had been used in Europe to promote healthy lifestyle behaviors among children.

## 5. Future directions and conclusions

To conclude, interventions combining diet and physical activity had favorable results in a series of health outcomes such as anthropometric parameters, biomarkers, and lifestyle behaviors. It should also be noted that most successful interventions included participation of children's parents, teachers' training, lasted for 1 school year and half of them were based on a theoretical model. Some effective strategies have been used, but one may argue that the one-size-fits-all approach may not be applicable to all settings. Future research should focus on improving the quality of the evidence and expanding implementation settings. More studies with rigorous study design are needed, in other words studies with an appropriate sample size, a relevant control group, an appropriate follow-up period well beyond post intervention, and the inclusion of validated measures of dietary and physical activity behaviors, measurements of body composition and assessment of engagement and sustainability issues.

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