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Systematic Review

Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature

Eveline Van Cauwenberghe[1]*, Lea Maes[2], Heleen Spittaels[1], Frank J. van Lenthe[3], Johannes Brug[4], Jean-Michel Oppert[5] and Ilse De Bourdeaudhuij[1]

[1]*Department of Movement and Sport Sciences, Ghent University, Watersportlaan 2, 9000 Ghent, Belgium*
[2]*Department of Public Health, Ghent University, Watersportlaan 2, 9000 Ghent, Belgium*
[3]*Department of Public Health, Erasmus University Medical Centre Rotterdam, PO Box 2040, 3000 CA Rotterdam, The Netherlands*
[4]*EMGO Institute for Health and Care Research, VU University Medical Centre, Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands*
[5]*Department of Nutrition, Université Pierre et Marie Curie, Pitié-Salpêtrière Hospital (AP-HP), Human Nutrition Centre Ile-de-France (CRNH-IdF), Paris, France*

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The objective of the present review was to summarise the existing European published and 'grey' literature on the effectiveness of school-based interventions to promote a healthy diet in children (6–12 years old) and adolescents (13–18 years old). Eight electronic databases, websites and contents of key journals were systematically searched, reference lists were screened, and authors and experts in the field were contacted for studies evaluating school-based interventions promoting a healthy diet and aiming at primary prevention of obesity. The studies were included if they were published between 1 January 1990 and 31 December 2007 and reported effects on dietary behaviour or on anthropometrics. Finally, forty-two studies met the inclusion criteria: twenty-nine in children and thirteen in adolescents. In children, strong evidence of effect was found for multicomponent interventions on fruit and vegetable intakes. Limited evidence of effect was found for educational interventions on behaviour, and for environmental interventions on fruit and vegetable intakes. Interventions that specifically targeted children from lower socio-economic status groups showed limited evidence of effect on behaviour. In adolescents, moderate evidence of effect was found for educational interventions on behaviour and limited evidence of effect for multicomponent programmes on behaviour. In children and adolescents, effects on anthropometrics were often not measured, and therefore evidence was lacking or delivered inconclusive evidence. To conclude, evidence was found for the effectiveness of especially multicomponent interventions promoting a healthy diet in school-aged children in European Union countries on self-reported dietary behaviour. Evidence for effectiveness on anthropometrical obesity-related measures is lacking.

Systematic reviews: Europe: School-based interventions: Healthy diet

A healthful diet during childhood and adolescence promotes optimal health, growth and cognitive development of the child and adolescent, and may contribute to the prevention of chronic disease in later life[1–5]. Evidence suggests that eating habits adopted early in life track to some extent into adulthood, while the transition from childhood into adolescence is often associated with unhealthful dietary changes[6–8]. It is therefore important to establish healthful eating behaviours early in life, and specifically focus on the transition from childhood to adolescence. Dietary recommendations for a healthful diet across Europe recommend consumption of at least five portions of fruit and vegetables a day, reduced intakes of saturated fat and salt, and increased consumption of complex carbohydrates and fibre[3,9]. However, dietary consumption surveys show that most European children and adolescents do not meet these guidelines[10–14]. Recent figures also show alarming and increasing numbers of obese and overweight children and adolescents in Europe, indicating that energy intakes are higher than energy needs[11]. Discussion about how to tackle the epidemic of obesity is currently high on the health policy agenda and effective health promotion remains a key strategy[11,15].

Abbreviation: RCT, randomised controlled trial.

* **Corresponding author:** Eveline Van Cauwenberghe, fax +32 9 264 64 84, email eveline.vancauwenberghe@ugent.be

Therefore, there is a need to develop and implement effective programmes and policies that will result in children and adolescents adopting healthier diets.

Schools are a crucial social environment for children and adolescents and many attempts have been made to utilise this environment to promote healthful behaviours in youth, including healthful eating habits[16–21]. School-based interventions have the potential to reach almost 100 % of children of school age of diverse ethnic and socio-economic groups in the European context. Furthermore, in most European Union countries, primary and secondary schools serve at least one meal every school day. Other influencing factors at school for eating behaviours are food and beverages available at school outside meals (e.g. vending machines and school stores) and nutrition education classes. Schools therefore represent an important setting to promote and provide healthy nutrition and nutrition education[1,11,15].

Until now, it is unclear how successful school-based efforts have been in improving the dietary habits of young people in Europe. Previous reviews have mostly dealt with the prevention of obesity[16,17,19–25] or focused only on one specific dietary behaviour[18,26–29]. In addition, these recently published reviews were often limited in scope; only controlled trials[16–21,24,26,27,29] or long-term studies[16,19,20,24,26] were accepted. Such a strong focus on inclusion of only the most rigorous internal validity designs may disregard promising interventions, for which such designs were not possible or inappropriate. Finally, most of the studies included in these reviews were carried out in the United States[16–18,20,22–29], raising questions about the applicability of these results in European countries given the very different school system and school nutrition situation, as well as differences in eating habits and obesity rates[11,14]. This is, to our knowledge, the first review that tries to systematically review the evidence for effectiveness from studies conducted across Europe on school-based healthful diet promotion among children and adolescents on changes in nutrition behaviours and body composition.

Methods

Literature search

The retrieval of published studies for the present review included a structured search in five electronic databases (PubMed, Web of Science, CINAHL, The Cochrane Library and MDConsult) from January 1990 up to and including December 2007. No language restrictions were applied. The search strategy was initially developed in PubMed and adapted for use in other databases. The search was run by one reviewer (E. V. C.) in October 2007 and was rerun in January and finally in June 2008 to be absolutely sure that all studies up to December 2007 were available through the electronic databases. The search strategy was designed to be inclusive and focused on three key elements: population (e.g. children and adolescents); intervention (e.g. school-based); outcome (e.g. diet and nutrition). In addition, reference lists of all retrieved articles and review articles[16–21,23,24,26,28,30–33] were screened for potentially eligible articles. Furthermore, a number of websites of research groups that conduct and publish systematic reviews of public-health and health promotion interventions were scanned. These strategies were complemented with a comprehensive search of the 'grey' literature, i.e. publications not published in indexed peer-reviewed journals and publications in other languages than English. The following electronic databases were searched: SIGLE; Social Care Online; British National Bibliography for Report Literature. Additionally, the supplements of 'International Journal of Obesity' and 'Acta Paediatrica' were hand searched. Finally, authors of relevant reports, abstracts and non-English articles, derived from the searches detailed earlier, were contacted and asked for additional information about their study. A complete and detailed summary of the search strategies used, including a full list of the search strings for each database, can be found in Web Extra 1 (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP + 9 + systematic + review%2F).

Selection of studies

To be eligible for inclusion, studies needed to (1) be conducted in European Union countries; (2) target young children (6–18 years old) in a school setting; (3) aim at the primary prevention of obesity and diseases related to obesity in which the main component or one of the components was the promotion of a healthy diet and (4) report effects on dietary behaviour or on anthropometrics. The studies in the present review were, however, not limited to interventions explicitly aiming to contribute to obesity prevention. Rather, all interventions that targeted dietary behaviours that may be associated with obesity risk were included. Furthermore, papers that deal with the implementation, feasibility, applicability or cost-effectiveness of the interventions were accepted for further review. There were no restrictions on study design, study duration, follow-up period, intervention strategies, control condition and on who delivered the intervention. Studies were considered regardless of their design because for public-health purposes, randomised controlled designs, considered to provide the strongest evidence regarding an intervention, are often unachievable and may even be found inappropriate[34–37]. In addition, it is stated that different types of evidence (i.e. observational, experimental, extrapolated and experience-based sources) are needed to develop effective strategies for public-health interventions[34–37]. Yet, in the review process, a distinction was made between evidence from stronger and from weaker study designs.

The following exclusion criteria were applied: (1) interventions that were conducted mainly outside the school setting (e.g. community and family); (2) interventions that were not designed for primary prevention (i.e. for the treatment of chronic diseases, aimed at obese children, aimed at treatment or management of eating disorders or aimed at malnourished children); and (3) studies that did not report the effects on dietary behaviour and on anthropometrics.

To identify the relevant studies, one reviewer (E. V. C.) reviewed all titles and abstracts generated from the searches. Articles were rejected on initial screening only if the reviewer could determine from the title and abstract that the article did not meet the inclusion criteria or did meet any of the exclusion criteria. If abstracts were not available or unable to provide

sufficient exclusion information, the entire article was retrieved to screen the full text. The evaluation of the full text articles was divided among four reviewers (E. V. C., H. S., I. D. B. and L. M.) to further refine the results using the aforementioned inclusion and exclusion criteria. The decisions were discussed and disagreements between the reviewers were resolved by discussion until consensus was reached.

Quality assessment

A standardised quality assessment tool, the Effective Public Health Practice Project Quality Assessment Tool for Quantitative studies 2003, was used to appraise the methodological rigour of the included studies[38]. The six criteria included for quality assessment were: the extent to which study participants were representative of the target population (i.e. 'selection bias'); study design (i.e. 'allocation bias'); control of confounders (i.e. 'confounders'); whether outcome assessors were blinded (i.e. 'blinding'); reliability and validity of the data collection tools (i.e. 'data collection methods'); the withdrawals and dropouts (i.e. 'withdrawals and dropouts'). Each criterion was rated as strong, moderate or weak, and then summed to obtain an overall score for each study. Studies with at least four criteria rated as strong and with no criteria rated as weak were given an overall rating of 'strong'. Those studies receiving less than four strong ratings and only one weak rating were given an overall rating of 'moderate', and those studies with two or more criteria rated as weak were given an overall study rating of 'weak'. Any comments on the analyses and on the integrity of the intervention were also collected, but these did not affect the overall rating of quality.

The quality assessment instrument was pilot tested independently by two of the reviewers (E. V. C. and H. S.) on four of the reviewed studies. The reviewers compared their ratings, and where disagreement was noted, discussions ensued until consensus on all ratings was achieved. The quality assessment of the remaining studies was completed by one reviewer (E. V. C.) and discussed with another reviewer (H. S.).

Data extraction

To review the characteristics of the included studies, one reviewer (E. V. C.) extracted detailed information into summary tables. Data extracted included study and intervention characteristics as well as effect indicators. Specific study and intervention characteristics that have been identified previously by health education experts as being crucial for evaluating evidence on public-health interventions were extracted[36,39–43]. The study characteristics included specifics about the study design, participants, context, outcome measures and instruments, and effect and process evaluation variables, and the intervention characteristics included specifics about the intervention components.

Grading of evidence

A rating system of levels of evidence of effect, based on previously used best evidence synthesis, was used to draw conclusions on effectiveness on dietary behaviour and anthropometrics[44–46]. Some important adaptations were made to the system because the present review included studies regardless of their design, and a slightly different quality assessment tool was used. The following five levels were distinguished based on the number, design, overall quality and overall effectiveness of studies: (1) strong evidence of effect: (i) at least two (cluster) randomised controlled trials (RCT) of strong quality or (ii) one (cluster) RCT of strong quality and at least two (cluster) RCT of moderate quality. For both situations, consistent results are required; (2) moderate evidence of effect: (i) one (cluster) RCT of moderate quality and at least one (cluster) RCT of weak quality, (ii) one (cluster) RCT of moderate quality and at least one controlled trial of strong quality, (iii) at least three controlled trials of strong quality or (iv) one controlled trial of strong quality and at least three controlled trials of moderate quality. For all situations, consistent results are required; (3) limited evidence of effect: (i) more than one (cluster) RCT of weak quality, (ii) one controlled trial of moderate quality and two controlled trials of weak quality or (iii) two controlled trials of weak quality and at least two before–after, cohort or longitudinal studies. For all situations, consistent results were required; (4) inconclusive evidence of effect: (i) only one study, (ii) multiple before–after, cohort or longitudinal studies or (iii) contradictory results; (5) no evidence of effect: more than one study with consistent results that no significant or relevant results were shown. Results were considered to be consistent if none of the relevant studies pointed in the opposite direction (i.e. a study with a deterioration as overall result) and a maximum 33 % of the studies reported mixed results.

The overall result of each study for effectiveness on anthropometrics and dietary behaviour was based on the following system. If at least one finding was significant in the intended direction and no significant findings were found in the opposite direction, it was considered to be an improvement (i.e. $++$). For example, if diaries and 24-h recall were used to assess dietary intake and according to the 24-h recall there was a positive significant effect but according to the diaries the intake was unchanged but did not deteriorate significantly, the outcome result for dietary behaviour was identified as an improvement. The same procedure was followed to indicate a deterioration (i.e. $--$), namely at least one finding was significant in the opposite direction and no significant findings were found in the intended direction. Furthermore, it was stated that the overall result was mixed (i.e. $++/--$) if at least one finding was found in the intended direction and one in the opposite direction. Finally, it was indicated that no effect (i.e. 0) was found if all the findings did not change significantly in any direction.

Data synthesis

Because of the heterogeneity of studies with respect to study design, intervention, participants, measures and outcomes, a meta-analysis was not conducted to estimate a pooled effect size. The present findings, therefore, resulted in a descriptive systematic literature review. In a stratified analysis, we assessed levels of evidence of effect for studies according to outcome measure (i.e. dietary behaviour and anthropometrics), type of intervention (i.e. educational, environmental and

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multicomponent, i.e. combining education and environmental changes) and target group population (i.e. populations with a low socio-economic background and ethnic minority populations) within each age group (i.e. children and adolescents).

Results

Literature search

The initial database search yielded 8991 publications (Fig. 1). After reviewing the titles or abstracts or both, the total was reduced to 287. Checking the references in these papers and in review articles produced an additional eight papers, and another eleven papers were brought up by manually searching journals and contacting authors. After completely reviewing the 306 articles, 223 publications were excluded because they did not meet one or more of the inclusion criteria. Almost all of the excluded publications were studies conducted outside Europe. Other main reasons for exclusion were that the studies dealt with an irrelevant intervention or that the effects on behaviour and on anthropometrics were not reported. Finally, two interventions were family-based instead of school-based and another two were treatment instead of prevention studies. Thus, fifty-six studies (reported in eighty-three articles) were included; forty-two studies (reported in fifty-three articles) focused only on nutrition, the results of which are presented here. Twenty-nine studies included children and thirteen included adolescents. Of the

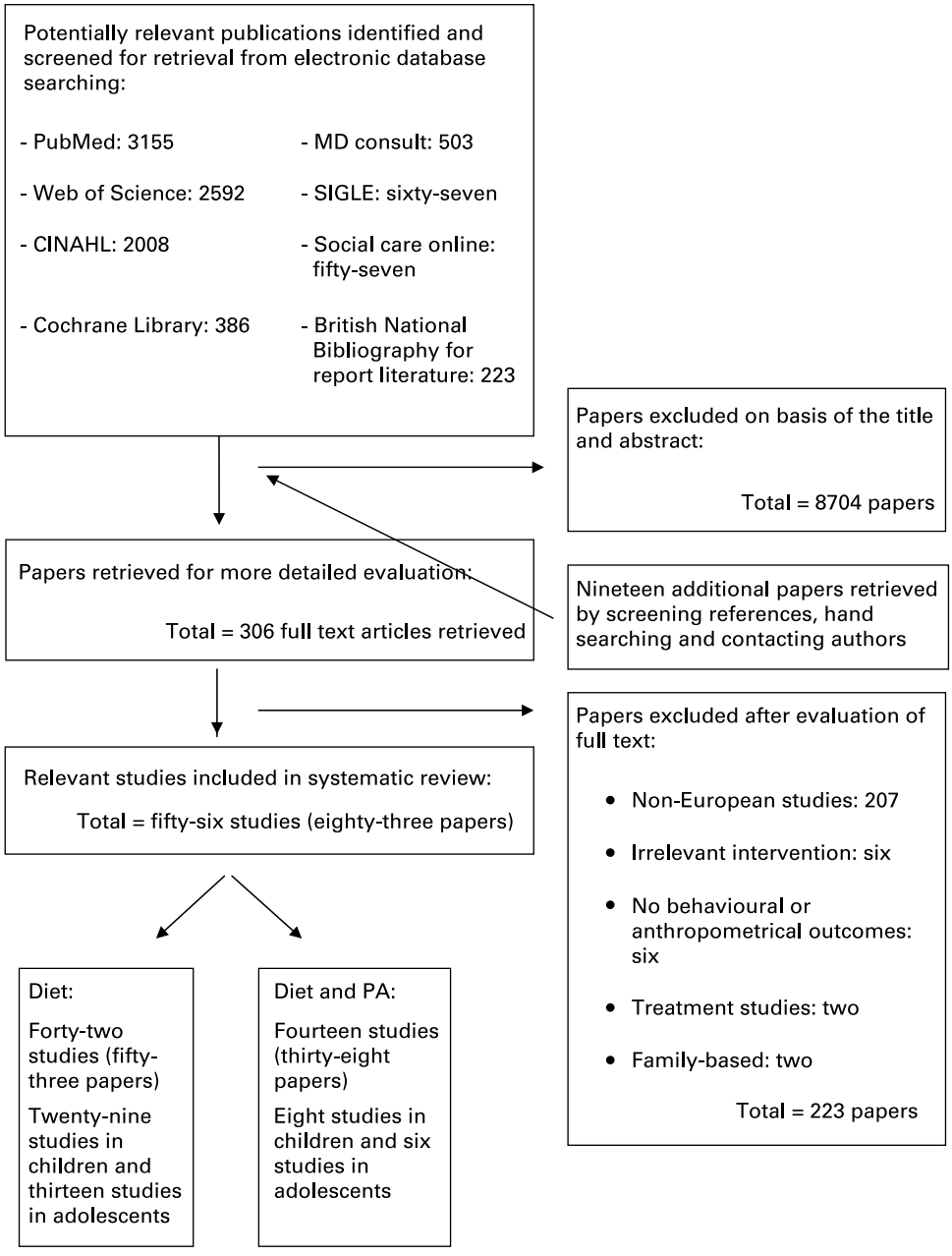

Fig. 1. Flow chart of study selection process. PA, physical activity.

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studies focusing only on nutrition, seven were 'grey literature'. Two studies in Italian[47,48], one study in German[49] and one study in French[50] were found through PubMed, and the authors were contacted for further information. One study[51] was retrieved by hand searching the supplements of the *International Journal of Obesity* and further information was again delivered by the author. In 2005, the final two studies[52,53] were briefly described in the article of Woolfe *et al.*, obtained through CINAHL, and further information about the two studies was collected by contacting the authors and the Food Standard Agency, London. An extensive table with a full description of the intervention characteristics and results can be found in Web Extra 2 and 3 (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP+9+systematic+review%2F). The studies were organised in the tables according to age group (i.e. children: 6–12 years old and adolescents: 13–18 years old) and the type of intervention (i.e. education-only, environmental or policy-based only or a combination of both: multicomponent). Follow-up periods (i.e. from baseline until follow-up measures) were divided into three categories: short term (<3 months), medium term (3–12 months) and long term (>12 months).

Methodological quality

The results of the quality assessment are presented in Web Extra 4 (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP+9+systematic+review%2F). Only five of the forty-two studies were overall rated as strong[54–58], eight were rated as moderate[52,59–65] and twenty-nine were rated as weak. All studies had some methodological weaknesses and none of the included studies fulfilled all the necessary quality criteria. In many studies, selection bias occurred. Only five studies[56,58,60,62,64] received a strong rating on this criterion. More mixed quality assessments were found for the criteria allocation bias (31 % scored weak, 40 % moderate and 29 % strong) and confounders (45 % scored weak, 7 % moderate and 48 % strong). Almost all of the studies used more than one method to measure dietary behaviours. In 76 % of the studies, dietary intake was collected by one of the following instruments: recall of food intake in the past 24 h; food diaries; food frequency checklists. Other methods that were used were self-developed questionnaires (*n* 9), observations (*n* 5), weighed measures (*n* 3) and sales data (*n* 2). Biomarker assessment, a more objective measurement method, was lacking in all of the studies. Because assessment of nutrition behaviour was self-reported, the blinding criterion, as stated in the dictionary of the tool[38], was not applicable in all of these cases. All the six studies[50,54,66–69] that measured body composition scored weak on blinding. Of all the measurement tools used, 49 % received a weak rating, 19 % a moderate rating and 32 % a strong rating on the criterion data collection methods. About 63 % of the studies reported a dropout between 0 and 40 %, and six studies[57,59,63–65,70] found differences between subjects who dropped out and who participated. Finally, a weak rating on the criterion withdrawals and dropouts was obtained in 43 % of the cases, a moderate rating in 20 % of the cases and a strong rating in 37 % of the cases. Regarding the statistical analyses, for most studies, a power calculation was not reported (60 %), studies failed to apply intention to treat analyses (60 %), and adjustment for clustering of data was lacking when randomisation was carried out at group level (40 %). To conclude, there appeared to be a risk for contamination in some of the included studies (24 %).

General characteristics of the studies

Study characteristics. Forty-two studies were included in the present review, twenty-nine in children and thirteen in adolescents. The study characteristics of each included study can be found separately for children and adolescents in Tables 1 and 2. Most of the studies in children and adolescents were carried out in the United Kingdom. Study population size varied from 40 to 6076 in the studies in children and from 54 to 4020 participants in the studies in adolescents. Three studies in children[53,71,72] and two in adolescents[68,69] were pilot studies. One-third of the studies in children[47,51,52,55,56,59,62,71,73–76] and just over half of the studies in adolescents[49,58,64,77–80] reported on process data such as appreciation, implementation, barriers, feasibility, subscription rates or opinions about the programme. Of those studies, only three studies[47,56,76] and one study[58], respectively, considered variation in integrity in analysing the effects of the programme. Short-term effects were reported in nine studies in children[52,55,61,71–73,81–83] and five studies in adolescents[58,65,78,79,84], medium-term effects in fifteen[47,48,51,54,56,57,59,60,62,63,67,70,83,85,86] and six studies[49,64,68,69,78,87], respectively, and long-term effects in eight studies[50,53,56,57,60,62,66,88] and one study[89], respectively. Although all of the projects conducted an outcome assessment at the end of the intervention period, only seven projects in children[53,55,56,60,63,86,88] and only four in adolescents[58,64,78,79] conducted a follow-up measurement some time after the intervention period had ended. Some studies aimed at specific target groups within the population at large. Eight studies in children[47,61,72,81,85,86,90,91] and four studies in adolescents[58,65,79,80] targeted children and adolescents from low socio-economic backgrounds, and two studies in children addressed ethnic minority groups[63,70]. All of the studies in children and adolescents targeted both boys and girls.

Intervention characteristics. The characteristics of the interventions of each included study are presented separately for children and adolescents in Tables 1 and 2. About half of the interventions among children[47,48,50–55,66,67,71,72,81,92] and among adolescents[58,64,65,68,78,84] were educational, consisting mainly of classroom-based activities (e.g. an adapted curriculum and distribution of educational materials). Six programmes in children[59–61,73,90,91] and two programmes in adolescents[49,89] used environmental modifications to stimulate a more healthful diet, namely increased availability and accessibility of healthy foods, subscription or distribution programmes, school lunch modifications and incentives. Another nine studies in children[56,57,62,63,70,82,83,85,86] and another five studies in adolescents[69,79,80,87,93] combined these two components. The duration of the interventions varied greatly between projects from a minimum of 2 weeks[71] to a maximum of 5 years[50,66] in children and from a minimum of 1 week[84] to a maximum of 2 years[80]

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Table 1. Study and intervention characteristics of included studies promoting healthy nutrition in children

First author (year)	No. of participants	Target group	Country	Follow-up period	Process evaluation	Intervention duration	Dietary behaviours addressed	Theory-based	Delivered by	Classroom-based
Educational interventions (*n* 14)										
Agozzino (2007)[47]	278	+	Italy	5 months	+	5 months	≠	+	E, T	+
Angelico (1991)[66]	150		Italy	5 years		5 years	≠		RT, T	+
Boaz (1998)[71]	99		United Kingdom	4 and 6 weeks	+	2 weeks	FV		RT	+
Bonaccorsi (2002)[48]	600		Italy	1 year		?	≠	+	RT, T	+
Borys (2000)[50], Heude (2003)[103], Lafay (1998)[104]	804 601 2364 1840		France	NA		5 years	≠		E, RT, SS, T	+
D'Addesa (2006)[51]	274		Italy	10 months	+	9 months	FV		E, RT, T	+
Friel (1999)[81]	821	+	United Kingdom	3 months		10 weeks	≠	+	RT, T	+
James (2004, 2007)[54,88]	644		United Kingdom	1 and 3 years		1 year	Soft drinks		RT, T	+
Livingstone (2002)[52], Woolfe (2005)[105]	305		United Kingdom	3 weeks	+	3 weeks	≠	+	RT, T	+
Mangukusumo (2007)[55]	486		The Netherlands	3 months	+	2 weeks	FV	+	SS, RT	+
O'Brien (2002)[72]	40	+	United Kingdom	6 weeks		4 weeks	≠		RT, T	+
Panunzio (2007)[67]	471		Italy	36 weeks		36 weeks	≠		E, RT, SS, T	+
Pearson (2002)[53], Woolfe (2005)[105]	65		United Kingdom	2 years		6 months	FV		E, T	+
Turnin (2001)[92]	1876		France	NA		5 weeks	≠		T	+
Environmental interventions (*n* 6)										
Bere (2005)[59]	795		Norway	10 months	+	10 months	FV		RT, SS	
Bere (2007)[60]	1950		Norway	9 and 45 months		9 months	FV		RT, SS	
Eriksen (2003)[73]	445		Denmark	7 weeks	+	5 weeks	FV		RT, SS	
Fogarty (2007)[90]	5606 5111 3382	+	United Kingdom	NA		2 years	F		SS	
Shemilt (2004)[61,75]	6076	+	United Kingdom	3 months and NA	+	?	Breakfast		SS	
Wells (2005)[91]	1492	+	United Kingdom	/		A few years	FV		SS	
Multicomponent interventions (*n* 9)										
Anderson (2005)[85]	294	+	United Kingdom	9 months		9 months	FV	+	RT, SS, T	+
Bere (2006)[56]	369		Norway	9 and 21 months	+	7 months	FV	+	RT, SS, T	+
Bere (2006)[62]	517		Norway	9 and 21 months	+	21 months	FV	+	RT, SS, T	+
Horne (2004)[86]	749	+	United Kingdom	5 months		16 d	FV		RT, T	+
Lowe (2004)[82]	402		United Kingdom	28 d		16 d	FV		RT, T	+
Pérez-Rodrigo (2005)[57], Te Velde (2008)[76], Wind (2006, 2008)[94,106]	1472		Norway, The Netherlands and Spain	8 and 20 months	+	2 years	FV	+	RT, SS, T	+
Ransley (2007)[83]	4595		United Kingdom	3 and 7 months		2 years	FV		SS, T	+
Reinaerts (2007)[70,74]	939	+	The Netherlands	9 months	+	9 months	FV	+	SS, T	+
Tak (2007)[63]	953	+	The Netherlands	1 year		1 year	FV		SS, T	+

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First author (year)	School-wide	School nutrition policy	Incentives	Screening + feedback	Teacher involvement	Peer leader involvement	Family involvement	School staff involvement	Community involvement
Educational interventions (*n* 14)									
Agozzino (2007)[47]					+		+		
Angelico (1991)[66]	+			+	+		+		
Boaz (1998)[71]							+		
Bonaccorsi (2002)[48]					+		+		
Borys (2000)[50], Heude (2003)[103], Lafay (1998)[104]	+				+		+	+	+
D'Addesa (2006)[51]	+				+		+		
Friel (1999)[81]					+		+		
James (2004, 2007)[54,88]					+				
Livingstone (2002)[52], Woolfe (2005)[105]				+	+				
Mangukusumo (2007)[55]				+			+		
O'Brien (2002)[72]	+				+		+		
Panunzio (2007)[67]					+				
Pearson (2002)[53], Woolfe (2005)[105]	+				+		+		
Turnin (2001)[92]					+				
Environmental interventions (*n* 6)									
Bere (2005)[59]	+	+						+	
Bere (2007)[60]	+	+						+	
Eriksen (2003)[73]	+	+							
Fogarty (2007)[90]	+	+							
Shemilt (2004)[61,75]	+	+						+	
Wells (2005)[91]	+	+							
Multicomponent interventions (*n* 9)									
Anderson (2005)[85]	+	+			+		+	+	
Bere (2006)[56]	+	+			+		+	+	
Bere (2006)[62]	+	+			+		+	+	
Horne (2004)[86]	+	+	+		+	+	+		
Lowe (2004)[82]	+	+	+		+	+	+		
Pérez-Rodrigo (2005)[57], Te Velde (2008)[76], Wind (2006, 2008)[94,106]	+	+			+		+	+	+
Ransley (2007)[83]	+	+			+		+		
Reinaerts (2007)[70,74]	+	+			+		+		+
Tak (2007)[63]	+	+			+				

E, experts; T, teachers; RT, research team; FV, fruit and vegetables; NA, not applicable; SS, school staff; F, fruit; +, present in the study; ≠, several dietary behaviours; ?, not reported in the study.

Table 2. Study and intervention characteristics of included studies promoting healthy nutrition in adolescents

First author (year)	No. of participants	Target group	Country	Follow-up period	Process evaluation	Intervention duration	Dietary behaviours addressed	Theory-based	Delivered by	Classroom-based
Educational interventions (*n* 6)										
Gratton (2007)[84]	198		United Kingdom	2 weeks		1 week	FV	+	RT, SS	+
Haerens (2007)[58]	304	+	Belgium	3 months	+	1 time	Fat	+	RT, T	+
Hassapidou (1997)[68]	126		United Kingdom	7 months		10 weeks	FV		E	+
Klepp (1993)[64]	447		Norway	5 and 12 months	+	4 months	≠	+	RT, T	+
Martens (2008, 2006, 2005)[65,77,107]	1613	+	The Netherlands	3 months	+	3 months	≠	+	T	+
Tsorbatzoudis (2005)[78]	335		United Kingdom	12 weeks and 5 months	+	12 weeks	≠	+	RT, T	+
Environmental interventions (*n* 2)										
Eicchorn (2007)[49]	475		Denmark	6 months	+	6 months	≠	+	SS, T	
Passmore (2005)[89]	2332		United Kingdom	2 years		2 years	≠	+	RT, SS, T	+
Multicomponent interventions (*n* 5)										
Ask (2006)[69]	54		Norway	5 months		4 months	≠		RT, SS, T	+
Loughridge (2005)[79]	2965	+	United Kingdom	3 months	+	1 month	Water and soft drinks		RT	+
Parker (2001)[80]	3197 3164 3989 3708 3227 4020	+	United Kingdom	NA	+	2 years	≠		RT, SS, T	+
Prell (2005)[87]	228		Sweden	10 months		?	Fish	+	E, RT, SS, T	+
Young (1993)[93]	158		United Kingdom	NA		?	≠		RT, SS, T	+

First author (year)	School-wide	School nutrition policy	Incentives	Screening + feedback	Teacher involvement	Peer leader involvement	Family involvement	School staff involvement	Community involvement
Educational interventions (*n* 6)									
Gratton (2007)[84]									
Haerens (2007)[58]					+				
Hassapidou (1997)[68]							+		
Klepp (1993)[64]					+	+	+		
Martens (2008, 2006, 2005)[65,77,107]				+	+		+		
Tsorbatzoudis (2005)[78]					+				
Environmental interventions (*n* 2)									
Eicchorn (2007)[49]	+	+			+	+		+	
Passmore (2005)[89]	+	+			+	+		+	
Multicomponent interventions (*n* 5)									
Ask (2006)[69]	+	+			+		+	+	
Loughridge (2005)[79]	+	+							
Parker (2001)[80]	+	+			+			+	
Prell (2005)[87]	+	+			+			+	
Young (1993)[93]	+	+			+		+	+	

No., number; FV, fruit and vegetables; RT, research team; SS, school staff; T, teachers; E, experts; NA, not applicable; +, present in the study; ≠, several dietary behaviours; ?, not reported in the study.

in adolescents. Ten studies in children[47,48,52,55–57,62,70,81,85] and eight studies in adolescents[49,58,64,65,78,84,87,89] evaluated an intervention, which was explicitly informed by one or more behavioural theories, a theoretical framework or an explicit theory-based planning model. The majority of the projects using a theory in children reported the use of the social cognitive theory[52,56,62] or the intervention mapping protocol[70,94]. In adolescents, the theory of planned behaviour was most frequently used[58,78,84,87,89]. The consumption of fruit and vegetables was promoted in more than half of the interventions in children[51,53,55–57,59,60,62,63,70,71,73,82,83,85,86,90,91], while in adolescents several dietary behaviours were addressed in more than half of the interventions[49,64,65,69,78,80,89,93]. All but three projects in children[61,90,91] and one study in adolescents[68] reported teachers or research staff as the primary intervention providers, while school staff and experts were involved occasionally in the delivery of the intervention. The intervention components were mainly delivered in the school setting, since this was an explicit inclusion criterion, but some projects in children involved additional family-based components[47,48,50,51,53,55–57,62,66,70–72,81–83,85,86] or additional community-based components[50,57,70]. Few projects in adolescents had additional family-based components[64,65,68,69,93]. Finally, some projects in children and adolescents reported the use of health screening plus feedback[52,55,65,66] and the use of peers[49,64,82,86,89].

Evidence of effect

Tables 3 and 4 present the components to calculate the levels of evidence of effect on anthropometrics and dietary behaviour in studies in children and adolescents. The study design, according to the Study Design Algorithm used by the Community Guide[95], the overall quality rating of each study and the overall effectiveness of each study are presented in these tables. It was found that 76 % of the studies in children resulted in an improvement in dietary behaviour and 25 % in body composition. In adolescents, this was 77 and 0 %, respectively. Ten studies in children and six studies in adolescents also measured the effects on dietary determinants. These results are not included in the present paper, but they can be found in Web Extra 3 (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP+9+systematic+review%2F).

Finally, Table 5 summarises the stratified levels of evidence for the effectiveness of interventions to promote healthy nutrition in children and adolescents.

Educational interventions in children. Fourteen studies evaluated the effect of education-only interventions in children on dietary behaviour, including two strong[54,55] and one weak[67] cluster RCT, one moderate[52] and three weak[51,71,81] controlled trials, and five weak before–after studies[47,48,53,66,72] and two weak prospective cohorts[50,92]. In six studies, effectiveness was not found[48,51,55,66,67,71] and in two studies mixed results were found[47,72]. Positive effects were found in the short term[52,81], the medium term[54], the long term[50,53] and in a prospective cohort[92], and in one study an improvement was mainly found in children from advantaged areas[81]. This equates to limited evidence that educational interventions in children can alter dietary behaviour positively.

Only four educational studies in children reported the effect on anthropometrics, including one strong[54] and one weak[67] cluster RCT, one weak before–after study[66] and one weak prospective cohort[50]. A well-executed study discouraging the consumption of carbonated drinks reported a positive effect on the prevalence of obesity after 1 year[54], but this effect was not sustained after 2 years[88]. However, no significant changes in BMI, centile *z*-scores and waist *z*-scores were found at both follow-ups. Two studies found significant negative effects in subgroups at medium term[67] and long term[50], and one study found no effect on BMI[66]. This provides inconclusive evidence that educational interventions can contribute to changes in body composition.

Environmental interventions in children. Five studies on fruit and vegetable subscription or distribution programmes and one breakfast distribution programme[61] assessed the effect on fruit and vegetable intakes and on breakfast habits, including one moderate cluster RCT[61], two moderate[59,60] and one weak[73] controlled trials and two weak prospective cohorts[90,91]. Effectiveness was found in the six studies, but only in one study a sustained effect at the long term was detected[60]. This suggests that there is limited evidence that environmental interventions can improve fruit and vegetable intakes and there is inconclusive evidence that environmental interventions can improve breakfast habits.

None of the interventions with environmental modifications in children measured the effect on body composition.

Multicomponent interventions in children. Nine multicomponent studies assessed the effect on fruit and/or vegetable intake, including two strong[56,94], one moderate[62] and one weak[85] cluster RCT, one moderate[63] and three weak[70,83,86] controlled trials and one weak before–after study[82]. All consisted primarily of a fruit and/or vegetables subscription or distribution programme combined with a nutrition education curriculum and all found an improvement in dietary behaviour. Eight studies reported effects in subgroups only[56,62,63,70,82,85,86,94] and five studies reported a long-term effect[56,57,62,83,86]. This provides strong evidence that multicomponent interventions can have a positive effect on fruit and vegetable intakes.

None of the multicomponent studies in children measured the effect on anthropometrics.

Educational interventions in adolescents. All the education-only programmes in adolescents measured the effect on dietary intake, including one strong[58], one moderate[65] and one weak[68] cluster RCT, one weak RCT[84] and one moderate[64] and one weak[78] controlled trial. Positive effects were almost always reported with one study reporting mixed results[65]. Furthermore, four studies reported effects in subgroups only[58,64,65,68] and in one study the effect was sustained after 1 year[64]. To conclude, there is moderate evidence that educational interventions in adolescents can improve dietary behaviour.

Inconclusive evidence of effect was found for education-only interventions in adolescents on body composition, with only one weak cluster randomised trial[68] measuring the effect on height and weight and reporting no significant change[68].

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Table 3. Study design, overall study quality and overall intervention effectiveness on anthropometrics and dietary behaviour of included studies promoting healthy nutrition in children

First author (year)	Study design	Overall study quality	Overall effectiveness on anthropometrics	Overall effectiveness on dietary behaviour
Educational interventions (*n* 14)				
Agozzino (2007)[47]	Before–after	Weak	/	Food intake: ++/−− Different effects according to implementation level
Angelico (1991)[66]	Before–after	Weak	BMI: 0	Food intake at school: 0
Boaz (1998)[71]	Non-RCT	Weak	/	Food intake: 0
Bonaccorsi (2002)[48]	Before–after	Weak	/	Food intake: 0
Borys (2000)[50], Heude (2003)[103], Lafay (1998)[104]	Prospective cohort	Weak	BMI and overweight, obesity prevalence: −− Different effects according to definition of overweight and obesity, sex and age	Food intake: ++
D'Addesa (2006)[51]	Non-RCT	Weak	/	Food intake: 0
Friel (1999)[81]	Non-RCT	Weak	/	Food intake: ++ Different effects according to SES
James (2004, 2007)[54,88]	Cluster RCT	Strong	BMI, prevalence of obesity and waist circumference: ++ No sustained effect	Consumption of carbonated drinks: ++ Sustained effect was not measured
Livingstone (2002)[52], Woolfe (2005)[105]	Non-RCT	Moderate	/	Food intake: ++
Mangukusumo (2007)[55]	Cluster RCT	Strong	/	Fruit and vegetable intakes: 0
O'Brien (2002)[72]	Before–after	Weak	/	Intake at school: ++/−−
Panunzio (2007)[67]	Cluster RCT	Weak	BMI and obesity prevalence: −− Only boys and girls from the nutritionist IG	Food intake: 0
Pearson (2002)[53], Woolfe (2005)[105]	Before–after	Weak	/	Food intake: ++ No different effects according to age and sex
Turnin (2001)[92]	Prospective cohort	Weak	/	Food intake: ++
Environmental interventions (*n* 6)				
Bere (2005)[59]	Non-RCT	Moderate	/	Food intake: ++ Different effects according to parent's education and habitual intake
Bere (2007)[60]	Non-RCT	Moderate	/	Food intake: ++ Sustained effect No different effects according to sex
Eriksen (2003)[73]	Non-RCT	Weak	/	Fruit and vegetable intakes: ++
Fogarty (2007)[90]	Prospective cohort	Weak	/	Fruit consumption: ++ No sustained effect No different effects according to SES
Shemilt (2004)[61,75]	Cluster RCT and prospective cohort	Moderate	/	Breakfast habits: ++ Only at medium term
Wells (2005)[91]	Prospective cohort	Weak	/	Fruit, fruit juice and vegetable intakes: ++ No sustained effect
Multicomponent interventions (*n* 9)				
Anderson (2005)[85]	Cluster RCT	Weak	/	Food intake: ++ Different effects according to sex
Bere (2006)[56]	Cluster RCT	Strong	/	Fruit and vegetable intakes: ++ Sustained effect Different effects according to enjoyment of the curriculum and usage of the newsletters No different effects according to implementation level and the presence of parents meetings
Bere (2006)[62]	Cluster RCT and non-RCT	Moderate	/	Fruit and vegetable intakes: ++ Sustained effect Different effects according to sex
Horne (2004)[86]	Non-RCT	Weak	/	Fruit and vegetable intakes: ++ Sustained effect Different effects according to baseline intake and age
Lowe (2004)[82]	Before–after	Weak	/	Fruit and vegetable intakes: ++ Different effects according to baseline intake and age

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Table 3. *Continued*

First author (year)	Study design	Overall study quality	Overall effectiveness on anthropometrics	Overall effectiveness on dietary behaviour
Pérez-Rodrigo (2005)[94], Te Velde (2008)[57], Wind (2008, 2006)[76,106]	Cluster RCT	Strong	/	Fruit and vegetable intakes: ++ Sustained effect Different effects according to country, baseline intake, appreciation, implementation and parental involvement
Ransley (2007)[83]	Non-RCT	Weak	/	Food intake: ++ Sustained effect
Reinaerts (2007)[70,74]	Non-RCT	Weak	/	Fruit and vegetable intakes: ++ Different effects according to age, sex and ethnicity
Tak (2007)[63]	Non-RCT	Moderate	/	Fruit and vegetable intakes: ++ Different effects according to ethnicity

/, Not measured; ++/−−, mixed results; 0, no effect; RCT, randomised controlled trial; ++, overall improvement; −−, overall deterioration; SES, socio-economic status; IG, intervention group.

Environmental interventions in adolescents. Two environmental programmes assessed the effect on behaviour, including one weak controlled trial[89] and one weak before–after study[49]. Both trials used a peer-based setting approach. A positive long-term effect on food intake at school was found in one study[89], equating to inconclusive evidence of effect.

None of the interventions with environmental modifications in adolescents measured the effect on anthropometrics.

Multicomponent interventions in adolescents. The five multicomponent programmes measured the effect on dietary intake, including a weak cluster RCT[69], two weak controlled trials[79,87] and two weak prospective cohort studies[80,93]. All programmes consisted primarily of a distribution programme or changes in the school lunch combined with a nutrition education curriculum. Effectiveness was found in four studies and one study reported mixed results[80], suggesting that there is limited evidence of effect.

Table 4. Study design, overall study quality and overall intervention effectiveness on anthropometrics and dietary behaviour of included studies promoting healthy nutrition in adolescents

First author (year)	Study design	Overall study quality	Overall effectiveness on anthropometrics	Overall effectiveness on dietary behaviour
Educational interventions (*n* 6)				
Gratton (2007)[84]	RCT	Weak	/	Fruit and vegetable intakes: ++
Haerens (2007)[58]	Cluster RCT	Strong	/	Fat intake: ++ Different effects according to education, sex, reading the intervention message and baseline self-rated stage of change No different effects according to attitudes
Hassapidou (1997)[68]	Cluster RCT	Weak	Height and weight: 0	Food intake: ++ Different effects according to sex
Klepp (1993)[64]	Non-RCT	Moderate	/	Food intake: ++ Sustained effect Different effects according to sex
Martens (2005, 2006, 2008)[65,77,107]	Cluster RCT	Moderate	/	Food intake: ++/−− Different effects according to baseline intake
Tsorbatzoudis (2005)[78]	Non-RCT	Weak	/	Food intake: ++ No sustained effect
Environmental interventions (*n* 2)				
Eicchorn (2007)[49]	Before–after	Weak	/	Food intake: 0
Passmore (2005)[89]	Non-RCT	Weak	/	Food intake at school: ++
Multicomponent interventions (*n* 5)				
Ask (2006)[69]	Cluster RCT	Weak	BMI and prevalence of obesity: 0	Food intake: ++
Loughridge (2005)[79]	Non-RCT	Weak	/	Water and soft drinks consumption at school: ++
Parker (2001)[80]	Prospective cohort	Weak	/	Food intake at school: ++/−−
Prell (2005)[87]	Non-RCT	Weak	/	Fish consumption at school: ++ No different effects according to sex
Young (1993)[93]	Prospective cohort	Weak	/	Food intake: ++

RCT, randomised controlled trial; /, not measured; ++, overall improvement; 0, no effect; ++/−−, mixed results.

Table 5. Summary of levels of evidence for the effectiveness of interventions promoting healthy nutrition in children and adolescents, stratified by intervention type and target group

	Children (twenty-nine studies)				Adolescents (thirteen studies)			
	Anthropometrics		Dietary behaviour		Anthropometrics		Dietary behaviour	
Variables	No. of studies	Level of evidence of effect	No. of studies	Level of evidence of effect	No. of studies	Level of evidence of effect	No. of studies	Level of evidence of effect
Intervention type								
Educational	4	Inconclusive	14	Limited	1	Inconclusive	6	Moderate
Environmental	0	Lacking	6	Limited	0	Lacking	2	Inconclusive
Multicomponent	0	Lacking	9	Strong	1	Inconclusive	5	Limited
Target group								
Ethnic minority populations	0	Lacking	2	Inconclusive	0	Lacking	0	Lacking
Low SES populations	0	Lacking	8	Limited	0	Lacking	4	Inconclusive

SES, socio-economic status.

Furthermore, in three studies the effect was only measured on food intake at school[79,80,87] and in one study a sustained effect at the long term was not found[80].

Inconclusive evidence was found for the effect of multicomponent interventions on body composition; the weak cluster randomised trial in which anthropometrics were measured did not find effects[69].

Children from low socio-economic backgrounds. All eight studies targeting children from low socio-economic backgrounds assessed the effect on dietary behaviour, including one moderate[61] and one weak[85] cluster RCT, two weak controlled trials[81,86], two weak before–after studies[47,72] and two weak prospective cohort studies[90,91]. Two studies reported mixed results[47,72], while the other studies reported improvements in dietary behaviour. This provides limited evidence that interventions targeted at children with a low socio-economic status are effective in changing dietary behaviour. None of the interventions specifically aimed at low socio-economic groups measured effects on body composition.

Children from ethnic minority populations. Only two studies evaluated the effect of an intervention in children from ethnic minority groups, including one moderate[63] and one weak controlled trial[70]. A significant positive effect on dietary intake was found in both studies, suggesting inconclusive evidence of effect. Both studies did not measure anthropometrics.

Adolescents from low socio-economic backgrounds. Four studies in adolescents targeted adolescents with a low socio-economic status, including one strong[58] and one moderate[65] cluster RCT, one weak controlled trial[79] and one weak prospective cohort study[80]. All four studies measured the effect on dietary behaviour. Two studies found an improvement in behaviour in this target group[58,79], while two studies found mixed results[65,80]. Furthermore, in two studies the effect was only found in a subgroup[58,65]. This suggests that there is inconclusive evidence that interventions in adolescents with low socio-economic backgrounds can change dietary behaviour positively. None of these studies measured the effect on body composition.

Adolescents from ethnic minority populations. None of the studies measured the effect in adolescents from ethnic minority populations.

Discussion

The purpose of the present review was to compile the evidence regarding the effectiveness of school-based programmes promoting a healthy diet on dietary intake and anthropometrics in children and adolescents in Europe. As the number of studies conducted among children was more than double and more studies in children were of higher quality, this resulted in more evidence of effect for interventions among children than among adolescents.

In children, there is strong evidence that multicomponent interventions that combine improved availability of fruit and vegetables with a nutrition education curriculum delivered by the teacher and at least some parent involvement can alter intake of fruit and vegetables. Furthermore, limited evidence of effect was found for nutrition education-only programmes delivered by teachers using practical activities such as taste testing, cooking classes, etc. Limited evidence of effect was also found for the effectiveness of programmes that only focused on environmental change. These were restricted to fruit and vegetables distribution programmes, either for free[59–61,90,91] or as a subscription programme[59,60,73]. For both schemes, evidence for effectiveness was found. Furthermore, inconclusive evidence of effect on dietary behaviour was found for environmental initiatives that targeted breakfast habits, for studies directed at children from low socio-economic backgrounds or ethnic minority groups. The present review also shows inconclusive evidence of effect of educational interventions on body composition, while this effect was never measured in the environmental and multicomponent interventions in children. For children, we can conclude that a range of fruit and vegetable promotion activities can be recommended for implementation and have a great chance of success, as all the environmental and multicomponent interventions including a fruit and vegetable provision scheme resulted in improvements in this behaviour. The European Commission has indeed issued implementation of such schemes across Europe (http://ec.europa.eu/health-eu/my_lifestyle/nutrition/index_en.htm). Whether fruit or vegetable promotion will meaningfully contribute to obesity prevention is rather doubtful, and more studies are needed that target a range of nutrition behaviours that contribute importantly to energy balance.

The same conclusion was found in a recent review investigating the effectiveness of worldwide interventions to promote fruit and/or vegetable consumption in children in schools, including fifteen studies from Europe, fourteen studies from the USA and one study from New Zealand[29]. Of the thirty studies included, 70 % increased fruit and vegetable intakes, with none decreasing intake. Nevertheless, of the seven school fruit and vegetables schemes targeting obesity reduction, only one study managed to produce positive impact on BMI and fruit and vegetable intakes.

In adolescents, moderate evidence was found for the effect of education-only interventions on dietary intake. Educational trials in adolescents usually provided a nutrition education curriculum that was delivered by the teachers. Besides, limited evidence of effect is provided for multicomponent programmes on dietary behaviour. The environmental part of these multicomponent trials consisted of adapting or increasing the availability of healthy food. This was combined with educating the adolescents about healthy nutrition by the teacher. In general, inconclusive evidence of effect of all these interventions was found on anthropometrics. As in children, it is also apparent in the trials for adolescents that there is an urgent need for dietary interventions in adolescents that measure the effect on overweight or obesity.

If we compare the present results with previous reviews including studies from outside Europe, similar conclusions were found. The most recent international review, reviewing the effectiveness of interventions improving the school food environment, has found effectiveness for school food policies on food intake, but little evaluation of the impact on BMI was found[25]. The present review included eleven studies from the USA and seven from Europe.

It is believed that parents play a direct role in children's and adolescent's eating patterns and consequently it is advocated that interventions, aimed at improving children's and adolescent's nutrition, need to address the family[96–98]. Furthermore, previous reviews concluded that the involvement of parents is an important determinant for success[18,21,26,28]. Many school-based interventions included in the present review included some parental involvement, 62 % of the studies in children and 38 % of the studies in adolescents. Although this was usually limited to newsletters, folders, homework assignments, or at best the organisation of some family nights at school, just over half of these interventions were successful in improving dietary behaviour making it difficult to come to a similar strong conclusion as in other international reviews[18,21,26,28].

The evidence of effect compiled in these European Union studies suggests a number of recommendations for future research in Europe. First, the present review showed that in the few studies that included anthropometric measures, the evidence on body composition was lacking or inconclusive. Only a limited number of studies measured anthropometrics and the studies that did were mostly 'low-dose' studies over short periods. Furthermore, most of the included studies were not explicitly aiming to contribute to obesity prevention and in the end obesity prevention is only partly a nutritional issue. Nevertheless, there is an urgent need for studies that include measures of body composition to fill the gap in the European literature. Second, more consensus is needed about 'best measures' for diet. This would help to increase comparability between studies and would facilitate assessment of effectiveness. Studies would also be stronger when self-reports, which could reflect a desire to report the 'right answer', would be verified with more objective monitoring[99,100]. Consequently, this illustrates the need for objective and validated outcome measures for dietary behaviour. Third, some studies only observed the effect on food intake at school[66,72,79,80,87,89]. This raises the question whether children might compensate during the rest of the day. It is therefore important to assess the effect of the intervention on total dietary behaviour. Fourth, more research is needed in specific groups. In general, more studies are needed in adolescents; specifically, older adolescents (16–18 years old) were never addressed in the included studies. Furthermore, socio-economic status and ethnicity are identified as determinants of healthy eating[101], but fewer interventions targeted children and adolescents from low socio-economic backgrounds[58,65,79,80] and from ethnic minority populations. Consequently, future research should address these populations. Fifth, it appeared that follow-up periods were relatively short, only 24 % of the studies in children and 9 % in adolescents reported long-term effects. Additionally, most of the interventions focused on short-term changes right after the intervention, 86 and 72 %, respectively, while it is essential to have measures of at least 6 months after the intervention to be able to study the retention of behaviour change and to detect if weight status is modified[39]. Studies with greater length are needed to make it possible to draw conclusions about the effectiveness on behaviour and obesity and about the sustainability of an intervention. Sixth, cost-effectiveness data were only provided in one study[75], while it is recommended that the efficiency of the intervention is also measured next to its effectiveness. Economic analyses and economic evidence must become a central part of prevention research. These are needed for appropriate policy decision making and for assessing long-term benefits[36,102]. Finally, a lot of the methodological shortcomings reported in the quality analysis were due to lack of information. So we advocate that researchers follow existing guidelines for reporting trials in the future[40,42]. Furthermore, the main reasons that studies received an overall low-quality rating were mainly due to a weak rating on the criteria selection bias and data collection methods. Consequently, European studies should try to do a better job on these quality criteria. In the same line, there is substantial evidence from the literature to suggest that the explicit use of theory will significantly improve the chances of effectiveness[39], but not all of the studies reported the use of a theoretical background. Especially, the educational and multicomponent studies relied on a theoretical background, while environmental interventions never reported a theoretical background. In the present review, it is not possible to conclude that a theoretical background is a key factor to success because both, studies that reported the use of a theory and studies that did not, showed effectiveness.

One of the major advantages of the present review is that we also collected grey literature and lower quality studies. In this way, the European evidence was broadened up, but grey literature and lower quality studies are useful information that is unfortunately excluded in many systematic reviews

that instead primarily focus on studies with rigid designs. Another advantage is that the present review looks specifically at the evidence available in Europe. European studies were the minority of included studies in other systematic reviews, which makes them hard to generalise to Europe. However, most of the studies included in the present review were carried out in countries from Western and Northern parts of Europe. This raises questions about the generalisability of these results to other countries in Europe, especially because contextual variables were often lacking in the included studies. To assess the usefulness of these strategies in the other parts of Europe, we would recommend replicating evaluations of the successful interventions identified in the present review adapted to a specific country and its culture.

Conclusion

Implications for policy makers

Various policy documents have called for the development of effective strategies to improve dietary habits in children and adolescents to help halt or reverse the increase in obesity and to improve other aspects of health.

In children, it appears that a subscription or distribution programme for fruit and vegetables combined with an educational component is likely to be effective to stimulate the consumption of fruit and vegetables. Educational programmes solely can also be effective in stimulating a healthy diet among children. Furthermore, evidence was found for fruit and vegetable subscription or distribution programmes on intake. Finally, studies in children from low socio-economic backgrounds seemed to be effective to improve dietary intake.

In adolescents, an educational programme is likely to be effective to promote healthy nutrition. Additionally, evidence was also found for programmes that adapted school lunches or increased the availability of healthy food and combined this with a nutritional curriculum on food intake.

To conclude, evidence of effect was found for European school-based initiatives that promote a healthy diet in school-aged children on behaviour. European evidence of effect was not established for school-based dietary interventions on obesity prevention. Furthermore, as discussed before, recommendations should not only be based on effectiveness, a lot of other factors such as sustainability, integrity, context and cost-effectiveness should also be considered to be able to deliver appropriate evidence-based recommendations to the policy makers.

Implications for research

Future research should focus on filling the gaps identified in the present review. To improve the quality of the evidence of effectiveness on these kind of interventions, it is important that high-quality studies are executed, namely studies with the most rigorous design as possible, an appropriate sample size, a follow-up beyond post intervention, the use of more objective measures of dietary behaviour, measurements of body composition and the assessment of implementation issues and cost-effectiveness. Next to high-quality studies, high-quality interventions are required. These are interventions with greater length and intensity as low-dose interventions over short periods are unlikely to induce improvements in behaviour and anthropometrics, sufficient integrity, and adequate involvement of the parents and schools. Furthermore, studies should be reported according to certain standards (e.g. CONSORT and the TREND statement), so that existing studies can be better compared and all the necessary information for the reader is delivered[40,42].

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