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Obesity Management

School-based interventions promoting both physical activity and healthy eating in Europe: a systematic review within the HOPE project

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Summary

It is the purpose of this study to systematically review the evidence of school-based interventions targeting dietary and physical activity behaviour in primary (6–12 years old) and secondary school (12–18 years old) children in Europe. Eleven studies (reported in 27 articles) met the inclusion criteria, six in primary school and five in secondary school children. Interventions were evaluated in terms of behavioural determinants, behaviour (diet and physical activity) and weight-related outcomes (body mass index [BMI] or other indicators of obesity). The results suggest that combining educational and environmental components that focus on both sides of the energy balance give better and more relevant effects. Furthermore, computer-tailored personalized education in the classroom showed better results than a generic classroom curriculum. Environmental interventions might include organized physical activities during breaks, or before and after school; improved availability of physical activity opportunities in and around the school environment; increased physical education lesson time; improved availability or accessibility of healthy food options; and restricted availability and accessibility of unhealthy food options. More high-quality studies are needed to assess obesity-related interventions in Europe.

Keywords: Europe, nutrition and physical activity intervention, obesity prevention, review.

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Introduction

The prevalence and degree of overweight and obesity in childhood and adolescence have rapidly increased worldwide (1–3). Primary prevention programmes could have a large impact on obesity by promoting healthy diets and sufficient physical activity in youngsters. Historically, most interventions have tried to prevent childhood obesity through health education focussing on individual-level behavioural determinants, such as increasing knowledge, awareness, attitudes and motivation (4,5). These interventions often focused on either nutrition or physical activity separately, and showed low to modest effects on behaviour and hardly any effects on BMI (6). In recent years, calls have been made for interventions that take into account the wider obesogenic environment (7) and as a consequence, interventions have been developed that try to systematically change the environment related to physical activity and/or nutrition to increase the likelihood of healthy behaviour.

Schools can be considered as an ideal setting for such interventions. A school's nutrition and physical activity environment can influence eating and physical activity behaviour in youngsters, via changes in food and beverages offered during meals and available on school premises (e.g.

vending machines, school stores, door to door class room sales), changes in physical activity during recess periods, sports and physical activity classes and improvements in facilities that support physical activity (e.g. changing rooms, sports equipment). At the same time, education programmes can influence more individual-level determinants (e.g. knowledge, attitudes). School policies, audiovisual cues, qualified staff, role modelling of teachers and incentives in the school's physical environment are other important factors amenable to change in order to improve health behaviour (8,9).

Several reviews have summarized the effectiveness of school-based interventions. The first reviews appeared in the late 1990s (10,11) and the most recent ones in 2009 (12) with many in between (13–24). With few exceptions, many of the interventions have been conducted in the USA and Australia, which raises questions about the applicability of these results in European countries.

The present review was conducted in the context of the HOPE project (Health Promotion through Obesity Prevention across Europe, http://www.hopeproject.eu), funded by the European Commission. This project aimed to integrate and enrich knowledge on the determinants of obesity in the European Union, in order to inform regional and national policies aiming to curb the obesity epidemic. Prevalence data show higher overweight and obesity rates in children in the USA compared with Europe (25). In most European countries physical education (PE), physical activity and sports are a mandatory component of the school curriculum with the number of hours of taught physical activity determined by national or regional legislation while this is not the case in the USA (26). In addition, home and school environments may be more walkable or bikable in European countries compared with USA or Australia. These differences might have an impact upon physical activity and nutrition interventions in schools and their effectiveness in different parts of the world. For example, strategies that focus on compulsory PE or on increasing activity levels during PE might show good evidence for the USA but not for Europe as many EU countries already have compulsory PE with dedicated PE teachers running the lessons.

As a consequence it is important to focus on specific European evidence in order to give public health guidelines and policy recommendations for the promotion of health behaviour and the prevention of overweight and obesity at the appropriate European level. In addition, the number of European studies has increased recently, which makes it relevant to review the literature.

In this review we summarize the evidence of school-based interventions that combined nutrition and physical activity approaches, and targeted children in primary (6–12 years old) and secondary (12–18 years old) schools in Europe.

Methods

Literature search

The retrieval of published studies for this review included a structured search in five electronic databases (Pubmed, Web of Science, CINAHL, The Cochrane Library and MDConsult) from 1990 up to and including December 2007. In addition, reference lists of all retrieved articles and review articles (10–24) were screened for potentially eligible articles. Furthermore, a number of web sites of collaborative groups that conduct systematic reviews of public health and health promotion interventions were scanned. These strategies were complemented with a comprehensive search of additional electronic databases: SIGLE, Social Care Online and British National Bibliography for Report Literature. Additionally, the supplements of 'International Journal of Obesity' and 'Acta Paediatrica' were handsearched. The search was run by one reviewer (EVC) in October 2007 and was rerun in January and June 2008. The search strategy was designed to be inclusive and focused on three key elements: population (e.g. children, adolescents), intervention (e.g. school-based) and outcome (e.g. diet, BMI). An exhaustive summary of the search strategies used, including a full list of the search strings for each database, can be found in Appendix S1 (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP+9+Review+PA+and+nutrition%2F) in Supporting information.

Selection of studies

European peer-reviewed papers from 1990 to December 2007 were considered. This review set out to include all interventions within the school setting aimed at the primary prevention of obesity and obesity-related diseases in which the main component or one of the components was the promotion of a healthy diet combined with physical activity in young people (6–18 years old). To be included, studies had to report at least the effects on behaviour or on measures of obesity. Studies were considered regardless of their design because randomized controlled designs, considered to provide the strongest evidence regarding an intervention, are often unachievable and may even be inappropriate. Different types of evidence (i.e. observational, experimental, extrapolated and experience-based sources) are needed to develop effective strategies for public health interventions (27–30).

The following exclusion criteria were applied: (i) non-European studies; (ii) studies published before 1990; (iii) interventions that were conducted mainly outside the school setting (e.g. community, family); (iv) interventions that were not designed for primary prevention (i.e. for the

treatment) and (v) studies that did not report the effect on behaviour and/or on measures of obesity.

To identify the relevant studies, one reviewer (EVC) 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 met any of the exclusion criteria. An evaluation of the full copies was conducted by a primary review team (EVC, HS, IDB and LM) to further refine the results using the aforementioned criteria. Disagreements between the reviewers were resolved by discussion until consensus was reached.

Quality assessment

A standardized quality assessment tool, the Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies 2003, to appraise the methodological rigor of the studies that met the inclusion criteria was used (31). The six criteria included for quality assessment were: (i) the extent to which study participants were representative of the target population; (ii) study design; (iii) control of confounders; (iv) whether outcome assessors were blinded; (v) reliability and validity of the data collection tools and (vi) the withdrawals and dropouts. Based on the extensive guidelines of the tool (31), 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 of the results or on intervention integrity were also retrieved.

The quality assessment instrument was pilot tested independently by two of the reviewers (EVC and HS) 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 (EVC) and discussed with another reviewer (HS).

Data extraction

To review the characteristics of the included studies, one reviewer (EVC) extracted detailed information into summary tables. Data extracted included intervention and study characteristics as well as effect indicators. Specific intervention characteristics that have been identified previously by health education experts as being crucial for evaluating evidence on public health interventions were extracted (28,32–36). Outcome measures were relevant measures related to obesity (e.g. BMI, skin-fold thickness), diet (e.g. fat intake, fruit and vegetable intake), physical activity behaviour (e.g. minutes of activity, active travel to school) and related behavioural determinants (e.g. attitudes, knowledge, social support, self-efficacy).

Grading of evidence

A rating system of levels of evidence, based on previously used best evidence syntheses, was used (37–39). Some adaptations were made because this review included studies regardless of their design. The following five levels were distinguished:

1. Strong evidence of an effect: (i) at least two (clustered) randomized controlled trials (RCTs) of high quality or (ii) one (clustered) RCT of high quality and at least two (clustered) RCTs of medium quality. For both situations a consistent effect is required.

2. Moderate evidence of an effect: (i) one (clustered) RCT of medium quality and at least one (clustered) RCT of low quality or (ii) one (clustered) RCT of medium quality and at least one controlled trial of high quality or (iii) at least three controlled trials of high quality or (iv) one controlled trial of high quality and at least three controlled trials of medium quality. For all situations, a consistent effect is required.

3. Limited evidence of an effect: (i) more than one (clustered) RCT of low quality or (ii) one controlled trial of medium quality and two controlled trials of low quality or (iii) two controlled trials of low quality and at least two before-after, cohort or longitudinal studies. For all situations, a consistent effect is required.

4. Inconclusive evidence of an effect: (i) only one study or (ii) multiple before-after, cohort or longitudinal studies or (iii) contradictory effects.

5. Evidence of no effect: more than one study with consistent results showing no significant or relevant effects.

Finally, if none of the relevant studies showed a significant effect in the opposite direction and a maximum of a third of the included studies reported mixed effects, we considered the overall effect to be 'consistent'.

Data synthesis

Because of the heterogeneity of studies with respect to study designs, interventions, participants, measures and outcomes, a meta-analysis was not conducted to estimate a pooled effect size. Our findings therefore resulted in a descriptive systematic literature review. We assessed levels of evidence for studies according to outcome measure (behavioural determinants, behaviour and measures of obesity), type of intervention (educational, environmental and multicomponent) and target group population (e.g. populations with a low socioeconomic background) within each age group (younger children and adolescents).

Results

Literature search

The initial multi-database search yielded 8991 publications (Fig. 1). The flow chart shows how these were reduced to 53 studies. Eleven studies (reported in 27 articles) focused on both nutrition and physical activity, the results of which are presented here (40–66). The studies focusing on nutrition alone are reported in a separate paper (67).

Of the 11 studies focussing on both nutrition and physical activity, six studies included young children and five studies included adolescents. An extensive table with a full description of the intervention characteristics and results

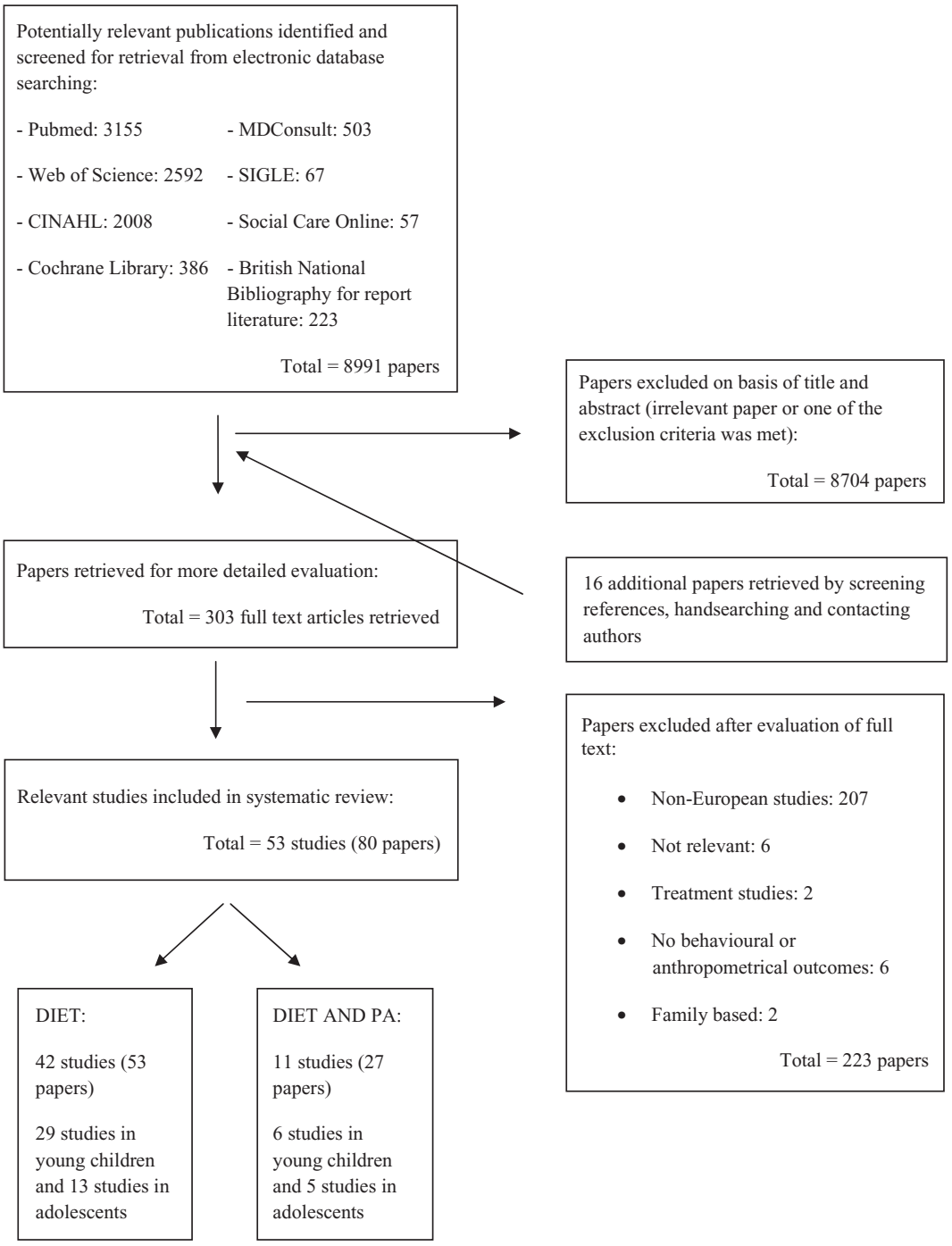

Figure 1 Flow chart of study selection process. PA, physical activity.

can be found in Appendix S2 (characteristics) and Appendix S3 (results) (http://www.hopeproject.eu/index.php?page=documents&documents_map=%2FWP+9+Review+PA+and+nutrition%2F) in Supporting information. The studies were grouped in the tables on the basis of age group ((i) children: 6–12 years old and (ii) adolescents: 13–18 years old) and the type of intervention ((i) educational only; (ii) environmental or policy-based only or (iii) a multicomponent combination of both). Follow-up periods (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

Table 1 presents a summary of the quality assessment. None of the 11 studies were overall rated as 'strong'. Ten were rated as 'moderate', and one was rated as 'weak'. More than half of the studies (7/11) got a 'strong' rating on the allocation bias criterion, which means that the majority of the studies included used a (clustered) randomized design. In most studies self-reports were used to measure diet, physical activity and related determinants; however, most studies used strong measures of anthropometrics (measured height and weight or skin-fold thickness).

Effects in primary school children

Table 2 presents a summary of the results of each study. Of the six studies promoting physical activity and healthy eating in young children, two focused on educational factors alone (40,66) and four others included educational and environmental elements in the intervention (41–44,49,50,53–58,60–63). The two studies focusing at educational factors alone used classroom lessons (66) or a board game (40) embedded in a nutrition and physical activity curriculum. These two studies found effects on nutrition knowledge. Effects on dietary and physical activity behaviour were only partial. For the BE SMART programme no overall dietary effect was found but there was a specific increase in playground activity at morning breaks (66). The KALEDO board game resulted in an increase in vegetable intake (40). Both studies also looked at effects on BMI, BMI z-scores or percentage overweight but no effects of the education interventions were found.

The four studies reporting on the effects of a multicomponent programme showed more favourable results than those only using education. These multicomponent programmes included an education component through classroom lessons, developing a nutrition and physical activity curriculum, and delivering materials as well as an environmental component, such as modifying school meals and tuck shops, increasing PE hours or active lesson time, providing playground equipment and activity, and meetings with parents and other community members. Two studies reported an increase in nutrition and/or physical activity knowledge (41–43,49,50,53–58,60,61). Strongest behavioural effects were found in the study of Manios *et al.* (49,50,53–58). The intervention had a positive effect on moderate to vigorous physical activity and on fat intake, even after a very long period of follow-up. No clear behavioural effects were reported in the Kiel Obesity Prevention Study (KOPS) study (41–43,60,61). Behavioural effects in the Children's Health Interventional Trial (CHILT) study were limited to an increase in coordination abilities (44).

Positive effects on BMI were mainly found in the study by Manios *et al.* (49,50,53–58), which also found strong behavioural effects. Analyses revealed smaller increases in BMI in the intervention children compared with control children, even 10 years after the intervention (50,57,58). The KOPS study (60,61) showed no overall effect on BMI but there was a consistent decrease in overweight in girls 4 years after the intervention. More specific effects were also found in subgroups (e.g. children from higher socioeconomic status families). The Active Programme Promoting Lifestyle Education in School (APPLES) and the CHILT study did not show effects on BMI (44,62,63).

Effects in adolescents

In adolescents, a total of five studies promoted physical activity and nutrition through the schools (Table 3), of which three studies used an educational approach (51,52,59) and two studies used both educational and environmental approaches (45–48,64,65). All three studies focusing on educational components alone were undertaken in the 1990s. The study by Lionis (52) included a health screening (medical examination) and theoretical and practical lessons in the curriculum, and this led to significant effects on physical activity and nutrition knowledge, but not on behaviour. Moon (59) implemented Healthy School Award Schemes focusing on school personnel, students and parents working together on a health education curriculum, but with no effect on dietary and physical activity determinants or on behaviour. The Oslo Youth Study (51) evaluated a school-based health education programme targeting students' eating patterns, physical activity levels and cigarette smoking after a 12-year follow-up period. No differences between the intervention and the control group were found for eating habits, but an effect on physical activity was detected, more specifically on vigorous exercise. Only one of these three (older) studies measured BMI or other obesity indicator: the study by Lionis (52) showed a smaller increase in BMI in the intervention group compared with the control group.

Two recent studies evaluated the implementation of a multicomponent programme in middle schools using educational (computer-tailoring) and environmental changes

Table 1 Quality ratings of included studies (based on the Quality Assessment Tool for Quantitative Studies (31))

Study	Selection bias	Allocation bias	Confounders	Blinding	Data collection methods*	Withdrawals and dropouts	Analysis	Intervention integrity	Overall rating
Primary school children									
Warren *et al.* (66)	Weak	Strong	Strong	Weak	Strong and weak	Strong and weak	• No power calculation; • No intention to treat analysis; • Group differences often not reported.	• Possible contamination	Weak
Amaro *et al.* (40)	Moderate	Strong	Strong	Weak	Strong and weak	Strong	• Post power calculation; • No intention to treat analysis.	• Possible contamination	Moderate
Sahota *et al.* (62,63)	Moderate	Strong	Strong	Weak	Strong and weak	Strong and Moderate	/	/	Moderate
Manios *et al.* Kafatos *et al.* (49,50,53–58)	Strong	Moderate	Strong	Weak	Strong and moderate	Strong and Moderate	• No power calculation; • No intention to treat analysis.	/	Moderate
Müller *et al.* Danielzik *et al.* (41–43,60,61)	Moderate	Strong	Strong	Strong	Strong and moderate	Weak	/	• Possible contamination	Moderate
Graf *et al.* (44)	Strong	Strong	Strong	Weak	Strong and moderate	Strong	• No power calculation; • No cluster analysis; • No intention to treat analysis.	/	Moderate
Secondary school children									
Lionis *et al.* (52)	Moderate	Moderate	Strong	Strong	Strong and weak	Strong and weak	• No power calculation; • No cluster analysis; • No intention to treat analysis.	• Possible contamination	Moderate
Moon *et al.* (59)	Weak	Moderate	Strong	Not applicable	Strong	Moderate	• No intention to treat analysis	• There was contamination	Moderate
Klepp *et al.* (51)	Moderate	Moderate	Strong	Not applicable	Weak and moderate	Moderate	• No power calculation; • No cluster analysis; • No intention to treat analysis.		Moderate
Singh *et al.* (64,65)	Strong	Strong	Strong	Weak	Strong	Strong	/	/	Moderate
Haerens *et al.* (45–48)	Strong	Strong	Strong	Weak	Strong and moderate	Strong and moderate	/	/	Moderate

*The criterion of 'collection methods' is based on validity and reliability of the measures used.

Table 2 Summary table of intervention effects in children (6–12 years old)

Children (6–12 years)	BMI	Other anthropometrics	PA	Nutrition	Determinants PA	Determinants nutrition
Education intervention						
BE SMART Warren *et al.* (66)	No effect	/	Playground activity	No overall effect	/	Knowledge
KALEDO Amaro *et al.* (40)	No effect	/	No effect	Vegetable increase	/	Knowledge
Education + environment intervention						
APPLES Sahota *et al.* (62,63)	No effect	/	No effect Increase in sedentary behaviour in overweight children	Vegetable increase Decrease in fruit and sugar in overweight children	/	/
Manios *et al.* Kafatos *et al.* (49,50,53–58)	Smaller increase in BMI	Smaller increase in skin-folds	Increase in MVPA	Less increase in fat	Knowledge	Knowledge
KOPS Müller *et al.* Danielzik *et al.* (41–43,60,61)	No effect Decrease in overweight in girls	/	/	/	/	Knowledge
CHILT Graf *et al.* (44)	No effect	/	Increase in coordination	/	/	/

APPLES, Active Programme Promoting Lifestyle Education in School; BMI, body mass index; CHILT, Children's Health Interventional Trial; KOPS, Kiel Obesity Prevention Study; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

Table 3 Summary table of intervention effects in adolescents (12–18 years old)

Adolescents (12–18)	BMI	Other anthropometrics	PA	Nutrition	Determinants PA	Determinants nutrition
Education intervention						
Lionis *et al.* (52)	Smaller increase	/	/	No effect	Knowledge	Knowledge
Moon *et al.* (59)	/	/	No effect	No effect	No effect	/
Klepp *et al.* (51)	/	/	Vigorous exercise	/	/	/
Education + environment intervention						
Singh *et al.* (64,65)	No effect	Skin-folds in girls	/	/	/	/
Haerens *et al.* (45–48)	Smaller increase in girls	/	MVPA School-related activity	Fat intake in girls	/	/

BMI, body mass index; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

based on the ecological model (45–48,64,65). A study in Belgium (45–48) found that in girls, a significantly larger decrease in fat intake was found in the intervention group compared with the control group after 2 years. In addition a smaller decrease in physical activity levels in both boys and girls was found in the intervention group. No, or very small, behavioural effects were found in a Dutch study (64,65). However, both studies succeeded in having an effect on measures of obesity: in the Belgian study (45–48), which found a lower increase in BMI in girls in the intervention groups compared with the control group 2 years after the intervention, although it found no effects on BMI or on other obesity measures in boys. Singh *et al.* (64,65) found no effects on BMI but found favourable changes in skin-fold thickness measures in boys and in girls.

Discussion

The purpose of this review was to compile evidence regarding the effectiveness of school-based programmes promoting a healthy diet together with healthy physical activity habits on behavioural determinants, healthy diets and physical activity habits, and measures of obesity in children and adolescents in Europe.

European studies constitute only a small proportion, perhaps 10%, of the studies reported in the international literature. Previous reviews of child obesity prevention have based their recommendations mainly on US research, undertaken within a US cultural context (10–24). For example, a review by Katz (17) specifically focussing on the effects of school-based strategies for the prevention and control of obesity concluded that a combination of nutrition and physical activity interventions is more effective at achieving weight reduction in school settings, than either nutrition or physical activity interventions alone. However, that review also included interventions on weight loss for overweight children. Other international reviews or meta-analyses focussing only on prevention did not find strong obesity prevention effects (13,68). The most recent review by Brown and Summerbell (12) on school-based interventions to prevent childhood obesity concluded that the findings were inconsistent, but that overall they suggested that combined diet and physical activity school-based interventions may help prevent children becoming overweight in the long term.

Our European review showed the following results: based on two recent studies by Haerens *et al.* (45–48) and Singh *et al.* (64,65) it could be concluded that there was moderate evidence that multicomponent interventions focussing on healthy diets and physical activity habits and combining an educational and an environmental component had a positive impact upon obesity measures in adolescent girls. Both interventions used a computerized online programme to provide adolescents with individually tai-

lored activity and nutrition feedback, and combined this with an environmental component for physical activity (including opportunities to be physically active during breaks, at noon or after school; organization of non-competitive activities; extra sports and PE classes) and for nutrition (including changes in school canteens; reduced price/increased availability of water and fruit and increased price/reduced availability of soft drinks and sweet desserts). These strategies can be considered to be promising in preventing overweight in adolescent girls in Europe. In the study of Haerens *et al.* (45–48), the effects on BMI could be explained by the behavioural effects: an increase in physical activity was found in both boys and girls, but dietary effects were only found in girls. This might suggest that changes in nutrition as well as activity habits are necessary to have a potential effect on BMI in adolescents.

In younger children (6–12 years old), there was inconclusive evidence that multicomponent interventions have a positive impact on child obesity in the European context. Two controlled studies of moderate quality showed no effects on BMI or other measures of obesity (44,62,63). One controlled study of moderate quality showed BMI effects in girls (43,61). Only the longitudinal study by Manios *et al.* (49,50,53–58) showed promising results on BMI and skin-folds. In this study, differences between the intervention and control group on obesity measures were persistent 3 years after the intervention, and even after 10 years the former intervention group pupils still had a lower average BMI than control pupils. The study also found positive changes in the pupils' physical activity levels and in their dietary patterns. The other studies showed no effects or very partial effects on both behaviours (41–44,60–63).

Interventions that include only an educational component without any environmental strategy seem to have little use in obesity prevention. In primary school children there was evidence that education-only interventions had no significant effect on BMI or other obesity measures (40,66). These studies also showed very partial behavioural effects: one study found effects on vegetable intake (40) and the other study found effects on playground physical activity levels (66). Both studies showed clear effects on knowledge. However, as other researchers have argued (5), increasing knowledge about health behaviour is not enough to change the behaviour itself or to influence health outcomes.

In secondary school children there was only limited evidence of effectiveness of education-only interventions on obesity measures. Lionis (52) found a smaller increase in BMI in the intervention group compared with the control group. No behavioural effects were found in this study, although there were effects on knowledge.

Some gender differences in the intervention effects were revealed, with more effects found on BMI or other obesity measures in girls compared with boys. This could not be due to different interventions delivered to boys or girls as all interventions were school-based and exposed boys and girls to the same extent. However, previous studies have found that women may be more susceptible of health information in general and also more responsive to nutrition education in particular (69). In contrast it is possible that men are more responsive to sports or physical activity interventions. This pleads for carefully designing studies in the future that offer the child more individually targeted forms of intervention.

A positive evolution in the design of studies can be observed over time. Whereas earlier studies focused mainly on educational intervention components, the newer ones included environmental strategies. Moreover, study designs became stronger, with the use of more objective measures, longer follow-up periods and specific attention to selection and allocation biases.

It should be noted that the studies included in the present review do not cover the whole European continent. Most of them were performed in the Western part of Europe (UK, the Netherlands, Belgium, Germany), some in Southern Europe (Italy, Greece) and only one in Northern Europe (Norway). No published studies were conducted in countries from the Eastern part of Europe and it should be acknowledged that within Europe large differences in school settings, nutrition and physical activity environments may exist. This means that interventions should be culturally adapted before they can be implemented in the different countries.

Some methodological issues are important to note. Based on the available European data, it was not possible to compute effect sizes on obesity measures or on behaviour. It is thus unclear whether the effects that were found were large, moderate or small. The detailed assessment of quality that was undertaken showed that most studies were of moderate quality. However, methodological shortcomings reported in the quality analysis were often due to lack of information. This argues for publishing more extensive methodological information about intervention trials. It should also be noted that a very broad diversity of studies was included in the present review, with observation periods ranging between 6 months and more than 10 years. This makes it difficult to make comparisons, and means that specific conclusions need to take the quality of the study design into account.

Additionally, the present review considered the effects of an intervention but did not review the processes. Process evaluation results, e.g. data on the implementation fidelity in the schools, might help us to interpret the data more accurately. Most studies included in the present review did not report on process evaluation results. Process evaluation data can play a role in a broader conceptualization of 'evidence of effectiveness' for evaluating health promotion programmes. As suggested by McQueen and Jones (30) the RCT should be questioned as the gold standard for assess-

ing effectiveness of health promotion interventions. An alternative system is needed for evaluating health promotion programmes that does not abandon the scientific approach or methodological rigour of the RCT.

Finally, possible publication bias may mean that this review gives a somewhat too positive picture of the effects of school-based interventions on nutrition, physical activity and obesity.

The present study has implications for research and policies. This review is the first to focus specifically on European evidence of school-based physical activity and nutrition interventions in children and adolescents. Given that a combination of approaches seems to be most effective, schools need to find ways to introduce these changes if they are not available yet. It might be preferable or even necessary that European schools are informed about the fact that combining educational and environmental strategies focussing on both nutrition and physical activity habits are necessary to prevent obesity in their pupils. It is possible that schools will need some further instruction, training or coaching to be able to implement these strategies locally. Policy initiatives may be warranted to attain this in the different countries.

Future research should in the first place replicate the statement that better effects on BMI or obesity are found by combining an educational and environmental component and focusing on both sides of the energy balance. These studies should preferably use effectiveness trials, with strong study designs, objective methods to measure behaviour, BMI and other outcomes, longer follow-up periods and specific attention to selection and allocation biases. Further research is also needed to investigate whether computer-tailored education is really superior to generic classroom-based education in youngsters.

A major research implication of this review is that time has come to move to the implementation of sustainable interventions under real life conditions. More research is needed on which interventions are effective and can also be implemented in the schools without a continued need for external help or support from a research team.

A further aim of the HOPE project was to build a model (EPHOPE model) to predict what would happen if increases of BMI are still continuing, and to contrast this with a scenario in which interventions can stop this increase or yield a decrease. The systematic review presented in this paper will help us to estimate this potential decrease and to feed this into the model to predict disability-free life expectancy. The EPHOPE model was constructed within the HOPE project and results from this model will be presented elsewhere.

In conclusion our results suggest that combining an educational and environmental component might be preferable in school-based nutrition and physical activity interventions to reduce obesity in European children and adolescents. These strategies should combine an educational component with environmental facilitation. Whether computer-tailored personalized education in the classroom is superior to a generic classroom curriculum is not yet fully understood, but results seem promising in adolescents. Environmental changes might include organized physical activity opportunities during breaks, or before and after school; after-school availability of activity space and equipment; increase of PE lesson time; easy availability or accessibility of healthy food; restrictions and rules on unhealthy food; and food pricing policies. If the primary focus is on the prevention of overweight and obesity in European children and adolescents, future studies of sufficient duration are needed so that (sustained) effects on BMI or other obesity indicators can be documented.

Conflict of Interest Statement

All authors gave consent to publication and disclosed no potential conflict of interest related to funding sources, relevant patents, financial and business relationships to sponsors, companies related to the research or the outcome of the studies in the manuscript, and this is in line with the publication ethics of the Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Strategies used to search the literature
Appendix S2. Characteristics of studies
Appendix S3. Study results

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