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Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 years

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Cade
Christian
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Abbreviations

CVD Cardiovascular disease
WHO World Health Organization

Abstract

Background: No reviews to date have assessed the impact of a range of multi- and single-component school based programs on daily fruit and vegetable intake using meta-analysis.

Objectives: The aim was to quantify the impact of school-based interventions on fruit and vegetable intake in children aged 5 to 12 years.

Design: A systematic literature review was carried out to identify randomized and non-randomized controlled trials based in primary schools and designed to increase portions of daily fruit and/or vegetable intake. Medline, Cochrane libraries, Embase, PsychInfo and Educational Information Centre were searched from 1985 to 2009. Data was extracted and mean effect sizes were calculated using random effects models.

Results: A total of 27 school-based programs involving 26,361 children were identified that met the inclusion criteria and assessed daily weight of fruit and vegetable intake combined, fruit intake only or vegetable intake only; and 21 were used in meta-analyses. The results of the meta-analyses indicated an improvement of 0.25 (95% CI 0.06, 0.43) portions of fruit and vegetable daily intake if fruit juice was excluded and an improvement of 0.32 (95% CI 0.14, 0.50) portions if fruit juice was included. Improvement was mainly due to increases in fruit consumption, not vegetables. The results of the meta-analyses for fruit (excluding juice) and vegetables separately indicated an improvement of 0.24 (95% CI 0.05, 0.43) portions and 0.07 (95% CI -0.03, 0.16) portions respectively.

Conclusions: School-based interventions moderately improve fruit intake, but have minimal impact on vegetable intake. Further studies are needed to address the barriers for success in changing dietary behaviour, particularly in relation to vegetables.

Introduction

The long-term health benefits of a diet high in fruit and vegetables in adulthood are well documented. High intakes of fruit and vegetables are associated with a reduced risk of all cause mortality (1) many cancers, (2-4) CVD (5-6) and determinants of CVD (7-11) major causes of death in developed countries. (12) High fruit and vegetable intakes may also be a risk factor for obesity (13) although this is disputed. (14-15) High fruit and vegetable intake is associated with a better quality diet lower in energy dense foods and higher in fibre. (16-18) and findings from the global Burden of Disease 2000 study suggest that 4.4% of the overall burden of disease in Europe is attributable to low intakes of fruit and vegetables. (19)

Childhood levels of fruit and vegetables may be related to intakes in later life (20) resulting in close links between poor intakes in childhood and adulthood. Surveys of children's fruit and vegetable intake have reported low intakes of fruit and vegetables in most American, European and Australian children of between 2 to 3 portions per day, (16, 21-28) well below the 5 portions (400g) recommended by many government departments of health. (29-30)

A range of potentially modifiable characteristics are reported to be associated with higher intakes of fruit and vegetables in children. These include good availability and accessibility, (31-38) taste preference and lack of neophobia, (34, 37, 39) better home support (40) knowledge of the national recommendations, (31, 41-42) interested in a healthy diet, (42-44) and verbal praise. (38, 45) These factors provide a wealth of information to shape the design of school and community based interventions to increase fruit and vegetable intake in children and have been incorporated into intervention programs. (46) Single component programs provide free or subsidized fruit to children to increase availability while multi-component programs provide a range of components such as nutrition education in the curriculum, improvement of the school environment to enable healthy choices, and communication with parents to increase family support.

A number of reviews of school programs to improve fruit and vegetable consumption have been conducted, (47-51) two of which have included a meta-analysis enabling the impact of programs to be quantified. Of the two reviews which included meta-analysis, one included a small number of studies (51) and one pooled studies where fruit and vegetable intake was assessed either over the school day or over the whole day, resulting in a high level of heterogeneity between studies. (47) This latter review may have overestimated the impact of

programs as it did not take into account the fact that children may potentially increase their consumption of fruit and vegetables while at school and compensate with reductions in home consumption. (52) This high quality review is the first to provide a meta-analysis of a wide range of multi-component and single component studies which measured the impact of school based programs on daily fruit and vegetable consumption. Advanced analysis techniques were used and the impact of programs was reported in terms of numbers of portions of fruit and vegetables. Important sources of heterogeneity were taken into account for the first time by presenting the results from studies which measured fruit and vegetables but not fruit juice. This is important as reviews of the health benefits of fruit and vegetables generally exclude juice which may have different associations with health outcomes. Results of the impact on fruit and vegetables separately are reported for the first time in meta-analyses.

Improvements in daily fruit and vegetable consumption have the potential to achieve significant public health benefits and this review identifies school-based trials targeting fruit and vegetable intake in children aged 5 to 12 years to assess the impact of these programs.

Methods

Search strategy

An unpublished protocol was designed and agreed by all authors at the start of the review. The following bibliographic databases were searched: the Cochrane Central Register of Controlled Trials, OVID MEDLINE (1986 to 2009), Global Health (1973 to 2009), PsychInfo (1987 to 2009), Educational Resources Information Centre (1985 to 2009), EMBASE and CINAHL. The search strategy method for MEDLINE included research terms in the following areas: child, fruit, vegetable, specific fruits and vegetables, public health, health behavior, health promotion, health education, intervention studies and diet. This was adapted so it could be used for the other databases, using keywords when MeSH terms were not available. Reference lists were searched for additional citations.

Inclusion and exclusion criteria

Dietary intervention studies in a school setting involving children aged between 5 and 12 years (at the start of the intervention) were included. Trials (with or without randomization) with a control or usual practice group were included. Studies were included if they used

standard assessment measures such as food diaries using weighed/non-weighed methods, 24 hour diet recall, or food frequency questionnaires.

Studies were excluded if the intervention focused on eating disorders, such as anorexia nervosa or bulimia, or if data on children of this age group could not be extracted separately from other age groups. Trials involving fewer than ten participants were also excluded as were those that included only obese children.

Trials were excluded if fruit and vegetable intake was measured solely on daily frequency of consumption of fruit and vegetables rather than amount or portions consumed using a standard portion size, as the weight of a piece of fruit or vegetable can vary. Studies were excluded if they did not include a measure of variation such as standard deviation or standard error. Studies were excluded if they did not report total daily fruit and vegetable consumption, for example if they reported consumption at school only. Studies that only had more than 2 years follow up were excluded as bias was likely to be considerable with loss to follow up.

Definitions of exposure and outcome

The main outcome was the difference in portions (total weight in grams/80g) of fruit and vegetables, separately and combined, consumed daily, excluding potatoes between the intervention and control group. This is the agreed portion size for fruit and vegetables and no government has set a smaller standard portion size for children.

The benefits of fruit juice consumption are not as clear as the benefits of fruit and vegetable intake. Therefore, trials that included fruit juice together with fruit and vegetables were analysed separately. Alternative wording from portion such as serving or serve were checked to ensure that this was equal to 80g. If the portion or serving was different from 80g this was recalculated. The US serving of half a cup of vegetables or medium size piece of fruit were taken to be equal to a portion of 80g.

Selection of the studies

Two independent reviewers were involved in the study identification and data extraction. In the first round of initial screening, the title and abstract of each article was checked for eligibility by one of the two reviewers. Articles were excluded from the title and abstract if they clearly did not meet inclusion and exclusion criteria as judged by the reviewer. In the second round of screening, full copies of potentially eligible articles were obtained and each

article was assessed for eligibility by both reviewers. Any disagreement between the two reviewers on whether the article was eligible was resolved by discussion between the reviewers, where necessary in consultation with a third reviewer.

Data extraction

Data was extracted by two independent members of the team (but not in duplicate). All the data extracted was checked by a third member of the team trained and experienced in data extraction. Data was extracted on data collection methods, length of program, drop-outs and analysis methods. All studies were summarized according to the following aspects: type of intervention, selection of population, outcomes, baseline and follow-up measures and statistical analysis. Data on sample size, sample age, date and location of the study, type of control group and unit of randomization were also extracted.

Wherever results for more than one follow-up period were reported, the longest follow up period was used in the meta-analysis. The different types of activities included in the intervention program were identified for each study. These included the following pre-specified elements: school lessons as part of the school curriculum; communications (either with parents through newsletters or with students and teachers at school); food provision such as availability of fruit and vegetables at lunchtime or in tuck-shops; free fruit and/or vegetable distribution, food marketing such as incentives to buy more fruit and vegetables at lunchtime including point of purchase incentives; food preparation and/or tasting during school; home based projects including home-work carried out with the help of parents; general improvements in the school environment (used if specific school based elements were not described); community and industry involvement such as supermarkets or industry partners. The final element reported by mainly US studies was goal setting and problem solving, which indicated an over-arching theory based study of planned behavior was used.

Quality assessment of studies

Assessment of the quality of the trials was based on three criteria; reporting of sequence generation criteria, allocation concealment and blinding of participants, personnel or outcome assessors. Trials were considered to be at high risk of bias if none of the criteria were met, at medium risk of bias if 1 or 2 of the criteria were met or at low risk of bias if all three of the criteria were met.

Statistical analysis

Statistical analysis was carried out in Stata version 10. Random effects models were used for all meta-analyses to determine pooled estimates of differences in portions of fruit and vegetables consumed in the intervention groups compared to control groups. If results were reported as change from baseline to follow up in each group difference between groups was calculated using the t-test. Heterogeneity was assessed using the I^2 statistic, which describes the proportion of total variation attributable to between-study heterogeneity. (53) I^2 values of less than 30% were considered to be low, values between 30-50% low to moderate, values between 50-75% moderate to high and values above 75% high. I^2 values of more than 50% indicate that caution should be used when drawing conclusions from the data.(54) Forest plots were examined to review heterogeneity between studies. Possible sources of heterogeneity were explored, and included: trial design (randomized or not randomized), geographical location, intervention type, diet assessment methodology, children's age and length of follow-up. Funnel plots were used to visually check for asymmetry and to determine the possibility of publication bias. (53)

Results

Literature search

The literature search outlined in the methods identified 2722 potential papers, including 316 duplicates (312 identified at the first stage and 4 identified at the screening stage): 592 papers from Embase, 100 from Psychinfo and the remainder from Medline. A total of 67 papers potentially meeting all the criteria as a result of screening titles and abstracts were identified. 2,656 papers were excluded (before de-duplication) based on the predetermined exclusion factors. Many papers were excluded on medical grounds such as eating disorders (12 studies), nut allergy (396 studies) or other medical conditions that concerned negative aspects of plants on health (711 studies). A number of papers were excluded where the outcome was not daily weight of fruit and vegetables (439 studies) or were not controlled trials (1072 studies). Some studies were excluded due to the age of the children (25 studies). Scrutiny of the remaining 67 papers identified 40 further papers for exclusion resulting in 27 studies remaining. Reasons for exclusion at this second stage are provided in **figure 1** with 'wrong age group and outcome other than daily weight of fruit and vegetables as the primary reasons for exclusion.

A summary of the studies included in the qualitative review on daily intake are displayed in **table 1**. The sample size of each study represents the number of children included in the analysis with baseline and follow up data available. The total number of participants included in all studies was 26,361 with a mean of 909 children per study (median of 486). Programs delivered a variety of interventions delivered over a range of 3 months for mainly curriculum based programs to two academic years for many of the more complex programs. The majority of the interventions consisted of more than one component and therefore were categorized as multi-component programs. These interventions often comprised a home and school element and tended to have a longer follow up time period than single component programs. The single component programs were mainly free or subsidized fruit distribution schemes. In most cases, control groups were either reported to receive an intervention at a later date or usual care. Some studies did not report information on the control group and two studies by Bere reported that the control group received a paid subscription for fruit compared to the intervention group which received free fruit.(55-56) The unit of randomization was normally the school but in two trials the unit of randomization was the class(57-58) and in one study was the region.(59) The median difference in daily fruit and vegetable intake between the control and intervention group for all studies included in the qualitative review was 0.6 portions based on 27 studies with intervention groups having higher intakes on average.

Six studies were excluded at the meta-analysis stage due to lack of measures of variation (standard deviation, standard error or confidence interval) (57, 60-64) One study reported total sample size but not sample size for each group. In this case the sample size was estimated by assuming equal numbers of children in each group and the study included. (65) One author replied to the request for further information on sample size for the control and intervention group and was also included. (66)

All papers included reported fruit and vegetable intake over the whole day but some also included fruit juice in the reported difference between groups.(65-68) Inclusion of fruit juice was a strong determinant of heterogeneity and therefore the primary analysis (see **figure 2)** included studies where only fruit and vegetables and not fruit juice were measured. Due to the fact that this was not decided a priori a sensitivity analysis including all studies was carried out in addition to the primary analysis (see **figure 3)**. Three studies in the meta-analysis reported total consumption of fruit and vegetables and also fruit juice (65-66, 68) while 9 studies reported weight of fruit and vegetables excluding fruit juice. In addition,

meta-analyses are presented with differences in daily fruit only (**figure 4**) and vegetable intake only (**figure 5**).

In the primary meta-analysis to determine differences in fruit and vegetable consumption excluding fruit juice, the pooled estimate for interventions reported a daily difference of 0.25 portions (95% CI 0.06, 0.43 portions) with higher levels of fruit and vegetables in the intervention group (figure 2). The difference between groups was significantly different from zero ($p<0.01$). The I^2 value was 49% (95% CI 0, 74%, $p=0.04$) indicating moderate levels of heterogeneity. A funnel plot indicated that there was some suggestion of slight asymmetry (plot supplied as supplementary data), but the Egger's test for asymmetry was not statistically significant ($p=0.58$). In the sensitivity analysis to determine differences in fruit and vegetable consumption including fruit juice, the pooled estimate for interventions reported a daily difference of 0.32 portions (95% CI 0.14, 0.50 portions) with levels of fruit and vegetables higher in the intervention group (figure 3). This difference was significantly different from zero ($p<0.01$). Heterogeneity measured using I^2 was moderate to high at 62% (95% CI 31, 79%, $p<0.01$). A funnel plot indicated that there was some suggestion of slight asymmetry (plot supplied as supplementary data), but the Egger's test for asymmetry was not statistically significant ($p=0.21$).

The meta-analysis of difference in fruit only, excluding fruit juice (figure 4) reported that fruit was 0.24 (0.05, 0.43) portions higher in the intervention group. This difference was significantly different from zero ($p=0.01$). However, heterogeneity was high with an I^2 value of 78% (95% CI 60, 87%, $p<0.01$). A funnel plot indicated that there was asymmetry (plot supplied as supplementary data), and the Egger's test for asymmetry was statistically significant ($p=0.02$). An analysis on all studies including those with fruit juice produced similar results. The difference between groups was 0.28 (95% CI 0.12, 0.44) portions for all studies which was significantly different from zero ($p<0.01$). Heterogeneity as denoted by I^2 was high at 78% (95% CI 63, 86%, $p<0.01$) (forest plot not shown). Differences in vegetable intake between control and intervention groups were much smaller (figure 5). A meta-analysis of vegetables only which included studies with fruit juice indicated an effect size of 0.07 (95% CI -0.03, 0.16) portions which was not significantly different from zero ($p=0.16$). Heterogeneity was moderate to high with an I^2 value of 72% (95% CI 54, 83%, $p<0.01$). A funnel plot indicated that there was some suggestion of slight asymmetry (plot supplied as supplementary data), but the Egger's test for asymmetry was not statistically significant ($p=0.60$).

An investigation into potential sources of heterogeneity using meta-regression analysis found no statistically significant associations between the estimates and whether schools were randomized, not randomized or not made clear, trial design (multi-component or single-component), age of the children, type of dietary assessment or length of follow up (see Table 2). However there were non-statistically significant trends in the pooled estimates for trial design. The pooled estimate for single-component studies was smaller, although heterogeneity was higher than for all studies combined. Five studies reported results for two follow-up periods. In three studies, Ransley,(52) Baranowski(66) and Reynolds,(65) the interventions continued beyond the first follow-up data collection point. In two studies (56, 69) the final follow-up collection period was more than three months after the completion of the intervention. Data reported at the latest follow up period was used for each study.

Quality of studies included in the meta-analyses

The quality of the 22 trials included in the meta-analyses was generally poor with evidence of high risk of bias. One study reported on all three criteria and was therefore judged to be at low risk of bias. (70) Ten studies reported on one or two criteria and were therefore judged to be at medium risk of bias. (52, 58, 63, 66-67, 71-75) The remaining 11 trials were judged to be at high risk of bias and did not clearly report sequence generation criteria, allocation concealment or blinding of participants, personnel or outcome assessors.

Discussion

Main findings

This review provides the first meta-analysis to quantify the impact of a range of school-based interventions on daily consumption of fruit and vegetable intake in children aged 5 to 12 years. It is also the first review to quantify the differences in impact on vegetable compared with fruit intake. School-based interventions of all types were estimated to improve daily fruit and vegetable consumption by an average of a quarter to a third of a portion; equivalent to 20-30g daily increase. Although most schemes aim to improve intake of both fruit and vegetables most fail to increase vegetable intake by a useful amount with most of the improvement in fruit intake. Studies that included fruit juice when assessing consumption of fruit and vegetables tended to have higher intakes of fruit, juice and vegetables at baseline and higher increases as a result of the intervention. Excluding fruit juice which is not

strongly associated with health outcomes attenuated the impact of programs on daily fruit and vegetable intake.

Comparison of different types of programs

School based interventions generally fall into two main categories, multi-component programs that motivate and engage children and families to change their eating behavior and single component programs that provide and distribute free or subsidized fruit and/or vegetables. In this review, the multi-component programs tended to result in larger improvements in fruit and vegetable intake but are diverse and can potentially be difficult to replicate without considerable time, man-power and funds.(48) How well interventions are implemented are reported to determine the impact of a program.(76-77) The single component studies including free and subsidized fruit and vegetable distribution schemes tended to be less effective although there were too few studies included to enable firm conclusions to be made. Distribution schemes have recently been introduced in some schools as part of national policies to increase children's fruit and vegetable intake. These schemes may offer little in terms of learned permanent improvement on children's eating habits; however fruit and vegetable intake may be moderately improved while receiving the fruit. Teachers rating programs for ease of use, rate distribution programs easier to implement than multi-component programs, (78) therefore long-term distribution programs may be a useful option for governments.

Comparisons with previous reviews

Previous reviews based on qualitative analysis without meta-analysis report increases of 0 to 1 servings of fruit and vegetables per day. (49) (50) The results obtained here are similar to those of a previous meta-analysis of seven studies, which reported an increase of 0.4 portions of fruit and vegetables. This previous review included mainly multi-component studies and did not exclude studies on the basis of including fruit juice which may explain the slightly higher effect. (51) A recent review of programs to improve fruit and vegetable intake stratified by type of intervention concluded that computer based interventions were the most successful type of program and multi-component programs had no impact. This conclusion was based on two analyses. Firstly a meta-analysis of only two programs using computer games, one of which did not include fruit and vegetable intake over the whole day (only the school day) and one of which included fruit juice. Secondly, the conclusions were based on an analysis of 7 multi-component programs, 6 of which improved fruit and vegetable intake

but due to high levels of heterogeneity as a result of including programs measuring only fruit or vegetable intake and programs assessing fruit and vegetable intake over part of the day, it was not possible to make firm conclusions.(47) In this review it was established that there are currently not enough studies assessing daily intake of fruit and vegetables to determine the impact of different types of studies although we identified a trend that multi-component studies are more effective than single component-studies.

Strengths of this review

This review had a number of strengths. A range of single and multi-component programs were included from different countries. Robust review methods were employed including the use of a range of databases to find papers from a variety of sources and the use of two reviewers to determine inclusions and exclusions. Furthermore, formal quantification of the pooled estimates was carried out using meta-analysis. Studies were included that reported frequency of consumption of fruit and vegetables as well as standard portion sizes or weight in grams.

Measures were taken to reduce heterogeneity by restricting age group and only including studies where standard methods of assessment were used. Fruit and vegetable intakes have been shown to be underestimated by some methods (79) but no substantial differences by assessment method were identified in this review. Studies that focused on obese children were excluded as they may be expected to be more prepared to change their diet than children in general.

Limitations of this review

The protocol was designed in 2008 using a Cochrane review protocol as a template and all authors were involved in the design and agreement of the protocol. However, the protocol is unpublished which is sub-optimal in meta-analysis.

Many studies published in this area are of poor quality design without a control group or with poor randomization methods leading to biased reporting. Reporting of results was not consistent and a number of studies did not report both fruit and vegetable consumption combined. Successful programs may not have been included in the analysis due to a lack of suitable published data on improvements in fruit and vegetable intake over the whole day.

Future strategies

Some components from earlier multi-component programs have been incorporated into national policy in some countries. For example, the curriculum in many countries includes specific lessons on healthy eating.(80) In the UK children aged 4 to 7 years receive free fruit and vegetables and receive a school meal meeting food based standards which include daily fruit and vegetable provision, both of which are elements of recent multi-component programs. However, there are some areas where very few, or no, trials have been reported in this age group, such as studies where cooking or school gardening is the main component. (81) Some types of studies such as tasting of fruit and vegetables were not included in the review because of a lack of assessment of daily fruit and vegetable intake in these mainly laboratory based studies; (82) however, exposing children who disliked vegetables for 14 days has been reported to increase liking and consumption of vegetables. (83) There is also evidence that schools participating in gardening programs increase fruit and vegetable, vitamin A, vitamin C and fibre intake. (84) Future RCTs in these areas may be expected to further contribute to an increase in the intake of vegetables in particular which is badly needed. There should also be a focus on families and home consumption of fruit and vegetables.

Very few studies collected follow-up data a full year after the intervention, particularly if the intervention was less than 6 months in duration. Those that did collect this type of data saw moderate long-term impact on fruit and vegetable intake, (56) indicating that if intervention programs are to have an impact on children's health they must run continuously over long periods of time and should not be considered as one-off solutions. Based on these results, school based programs could be expected to increase fruit and vegetable intake by a quarter to a third of a portion, but there is limited evidence of the impact on future health outcomes from a daily increase of a third of a portion of fruit and vegetables at a population level.

In conclusion, school-based programs including distribution schemes have the potential to moderately improve daily consumption of fruit. However these programs do not appear to be successful at improving vegetable intake in school-children. More efforts are needed to design programs to improve vegetable intake in children and to reduce barriers to positive behavior change.

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CE put forward the initial idea to carry out the review, contributed to the searching, analysed the data using meta-analysis, wrote the first draft and contributed to following drafts. MC was involved in producing the original search criteria, the searching of papers and contributed to all drafts. CC managed the search database, determined trial quality and contributed to all drafts. DG provided essential statistical support for all analysis and contributed to all drafts. JC provided essential support at all stages of the review and contributed to all drafts. We are grateful to Camilla Nykjaer for checking the data. No conflict of interest was identified by any of the authors.

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Table 1: Characteristics of studies included in the review of school-based interventions to increase daily fruit and vegetable (veg) intake. Difference in fruit and vegetable portions between groups is adjusted for baseline whenever possible. Banded rows are not included in the meta-analysis.

Study name (author, year published, country)	Sample size	Sample age	Intervention time: elements included in the intervention	Follow-up period from start of intervention	fruit & vegetable intake in portions at follow up		Difference in fruit & vegetable portions	Difference in fruit portions	Difference in vegetable portions
					Control	Intervention			
Nutrition Education Intervention (Anderson, 2005, UK)(71)	129	6-11 years	9 months: Curriculum, communications, food provision & marketing, food preparation/tasting	9 months	163g (2.0)	235g (2.9)	0.9	0.9	0
Gimme 5 (Baranowski, 2000, USA)(66)	3347	Mean of 8 years	9 months: Curriculum, communications, food marketing, goal setting & problem solving, home based projects	9 months	2.1 (1 year)	2.3 (1 year)	0.2	n/a	n/a
				21 months	2.1 (2 year)	2.3 (2 year)	0.2		
Squire's Quest (Baranowski, 2003, USA)(67)	1489	8-12 years	5 weeks: 10 session psycho-educational multimedia game	< 3 months	n/a	n/a	0.9	0.5	0.2
School Fruit Program (Bere, 2005, Norway)(69)	556	11-12 years	9 months: Free school fruit & veg distribution	9 months	1.0 (median)	2.0 (median)	1.0	n/a	n/a
Free School Fruit (Bere, 2006, Norway)(55)	517	10-11 years	21 months: Free school fruit & veg distribution	9 months	1.84	2.47	0.6	n/a	n/a
				21 months	1.57	2.09	0.5	n/a	n/a
Fruit & Veg Make the Marks (Bere, 2006, Norway)(56)	369	11 years	9 months: Curriculum, communications, food preparation, goal	9 months	2.12	2.20	0.1	n/a	n/a
				21 months	2.14	1.94	-0.2	n/a	n/a

Study name (author, year published, country)	Sample size	Sample age	Intervention time: elements included in the intervention	Follow-up period from start of intervention	fruit & vegetable intake in portions at follow up		Difference in fruit & vegetable portions	Difference in fruit portions	Difference in vegetable portions
					Control	Intervention			
			setting, home based projects						
Action Schools! (Day, 2008, Canada)(85)	444	10 years	3 months: Curriculum, food tasting, school environment, goal setting	3 months	2.68	2.55	-0.23	0.13	0.1
Fruit & veg subscription (Eriksen, 2003, Denmark)	313	6-10 years	1.5 months: fruit and vegetable subscription	1.5 months	3.1	3.5	0	n/a	n/a
5 a Day Power Play! School only (Foerster, 1998, USA)(60)	2684	7-9 years	2 months: Curriculum, school environment	3 months	2.3	2.9	0.6	n/a	n/a
5 a Day Power Play! School & community (Foerster, 1998, USA)(60)		7-9 years	2 months: Curriculum, school environment, community	3 months	2.3	3.3	1.0	n/a	n/a
The National Schools Fruit Scheme (Fogarty, 2007, UK)(64)	3382	7-8 years	12 months: fruit distribution scheme	24 months	2.0	1.7	0	n/a	n/a
School Nutrition Policy initiative (Foster, 2008, USA)(86)	774	Mean of 11 years	21 months: education, policy, social marketing and parent outreach	21 months	4.3	4.2	0.0	n/a	n/a
Eat Well & keep moving (Gortmaker, 1999, USA)(87)	336	Mean of 9 years	21 months: Curriculum, school environment, home based projects	21 months	2.8	3.6	0.7	n/a	n/a

Study name (author, year published, country)	Sample size	Sample age	Intervention time: elements included in the intervention	Follow-up period from start of intervention	fruit & vegetable intake in portions at follow up		Difference in fruit & vegetable portions	Difference in fruit portions	Difference in vegetable portions
					Control	Intervention			
Planet Health (Gortmaker, 1999, USA)(88)	593 boys 564 girls	Mean of 11.7 years	21 months: Curriculum, home based projects	21 months	3.6 3.9	3.6 3.6	0.2 0.3	n/a	n/a
American Indian Nutrition (Govula, 2007, USA)(68)	33	8-11 years	2 months: Curriculum	3 months	4.7	4.9	0.2	-0.5	0.7
Cardiovascular Exercise and Nutrition Program (Hopper, 1996, USA)(57)	97	7-9 years	3 months: Curriculum, home based projects	3 months	3.9	4.4	0.4	n/a	n/a
Food Dudes (Lowe, 2004, UK)(62)	36	4 to 7 years	1 month: social marketing using videos as part of curriculum	1 month	n/a	n/a	1.9	n/a	n/a
		8 to 11 years			n/a	n/a	1.6	n/a	n/a
Internet tailored advice (Mangunkusumo, 2006, The Netherlands)(58)	486	Mean of 10.3 years	3 months: Internet based feedback from questionnaire	3 months	2.14	2.06	0	0	0
School Fruit Tuck Shops(Moore, 2008, UK)(70)	1612	10-11 years	9 months: school environment (tuck shops selling fruit)	12 months	2.5	2.5	n/a	0.1	n/a
5 a day Power plus (Perry, 1998, USA)(72)	407	9-10 years	9 months: Curriculum, school environment, food provision/	12 months	4.7	5.2	0.6	0.6	0

Study name (author, year published, country)	Sample size	Sample age	Intervention time: elements included in the intervention	Follow-up period from start of intervention	fruit & vegetable intake in portions at follow up		Difference in fruit & vegetable portions	Difference in fruit portions	Difference in vegetable portions
					Control	Intervention			
			marketing, home based projects, industry involvement						
School Fruit & Vegetable Scheme: remaining on scheme at 7 months (Ransley, 2007, UK)(52)	3405	5 years	6 months: Free school fruit & veg distribution	3 months	3.3	n/a	0.7	0.6	0
				7 months	3.2	n/a	0.2	0.3	-0.2
School Fruit & Vegetable Scheme: leaving scheme by 7 months (Ransley, 2007, UK)(52)		6 years	6 months: Free school fruit & veg distribution	3 months		n/a	0.5	0.5	0
				7 months		n/a	-0.2	0	-0.3
Fruit & veg distribution program (Reinaerts, 2008, The Netherlands)(75)	436	Mean of 8 years	9 months: Free school fruit & veg distribution	9 months	1.7	2.0	0.3	0.3	0
				21 months	1.66	1.87	0.1	0.1	0
Multicomponent program (Reinaerts, 2008, The Netherlands)(75)	351	Mean of 8 years	9 months: Curriculum, food provision, communications, home based projects, community	9 months	1.65	1.82	0.2	0.2	0
				21 months	1.66	1.79	0.1	0.1	0
High 5 (Reynolds, 2000, USA)(65)	1426	Mean of 8.7 years	21 months: Curriculum, food tasting, problem solving, food service, home based projects	1year	2.28 (1 year)	3.96 (1 year)	1.7		
				2 years	2.21 (2 year)	3.20 (2 year)	1.0		
APPLES (Sahota, 2001,	593	Mean of	9 months: Curriculum,	12 months	2.5	2.5	-0.1	-0.2	0.1

Study name (author, year published, country)	Sample size	Sample age	Intervention time: elements included in the intervention	Follow-up period from start of intervention	fruit & vegetable intake in portions at follow up		Difference in fruit & vegetable portions	Difference in fruit portions	Difference in vegetable portions
					Control	Intervention			
UK)(74)		8.4 years	school environment, food service						
WAY program (Spiegel, 2006, USA)(63)	1007	9-11 years	9 months: Curriculum, problem solving, home based projects	9 months			0.55	0.1	0.45
Schoolgruiten project (Tak, 2007, Netherlands)(89)	450 (white)	9-12 years	9 months: Free school fruit & veg distribution	12 months	2.54	2.83	n/a	n/a	0.1
	236 (ethnic)				3.07	3.3	n/a	n/a	0
APPLE (Taylor, 2007, New Zealand) (59)	288	5-12 years	9 months: Curriculum, free fruit and veg, home based projects	12 months	3.2	3.6	1.1	0.8	0.3

Table 2: Pooled effects of studies which excluded and included fruit juice on daily portions of fruit and vegetable consumption by subgroup analysis stratified by randomization method, study design, length of follow up, type of dietary assessment and children's age.

Variables	No. of studies	Pooled estimate for sub-group (95% CI)	I^2 (%)	P value for heterogeneity within sub-group	P value for heterogeneity between sub-groups
Studies excluding fruit juice					
Randomization					
Randomized	4	0.26 (0.12, 0.40)	1	0.39	
Not randomized	4	0.26 (-0.17, 0.69)	69	0.02	0.83
Unclear	3	0.35 (-0.28, 0.98)	68	0.04	
Study design					
Multi-component	8	0.29 (0.08, 0.49)	40	0.11	0.47
Single component	3	0.15 (-0.26, 0.56)	67	0.05	
Length of follow up					
2 school years	6	0.26 (0.05, 0.47)	49	0.08	
1 school year	3	0.08 (-0.29, 0.46)	48	0.15	0.90
Less than 1 school year	2	0.72 (0.14, 1.30)	0	0.53	
Type of dietary assessment					
24hr recall	5	0.46 (0.07, 0.86)	54	0.07	
Un-weighed diary	3	0.08 (-0.29, 0.46)	48	0.15	0.31
FFQ	3	0.24(0.08, 0.40)	11	0.32	
Mean age of children	16	0.02 (-0.07, 0.11)			0.68
Studies Including fruit juice					
Randomization					
Randomized	5	0.24(0.12, 0.35)	0	0.51	
Not randomized	5	0.33(-0.13, 0.08)	67	0.01	0.40
Unclear	4	0.54(-0.04, 1.12)	78	<0.01	
Study design					
Multi-component	10	0.36(0.16, 0.56)	62	0.01	0.48
Single component	4	0.22(-0.25, 0.7)	68	0.03	
Length of follow up					
2 school years	8	0.33(0.12, 0.54)	68	0.33	
1 school year	3	0.08 (-0.29, 0.46)	48	0.15	0.88
Less than 1 school year	3	0.82(0.20. 1.45)	10	0.33	
Type of dietary assessment					
24hr recall	6	0.58(0.20, 0.96)	64	0.02	
Un-weighed diary	4	0.12(-0.11, 0.35)	39	0.18	0.14
FFQ	4	0.22(-0.02, 0.46)	42	0.16	
Mean age of children	20	0.01(-0.95, 0.11)			0.86

Figure 1: Flow diagram indicating number of studies included at each phase of the review

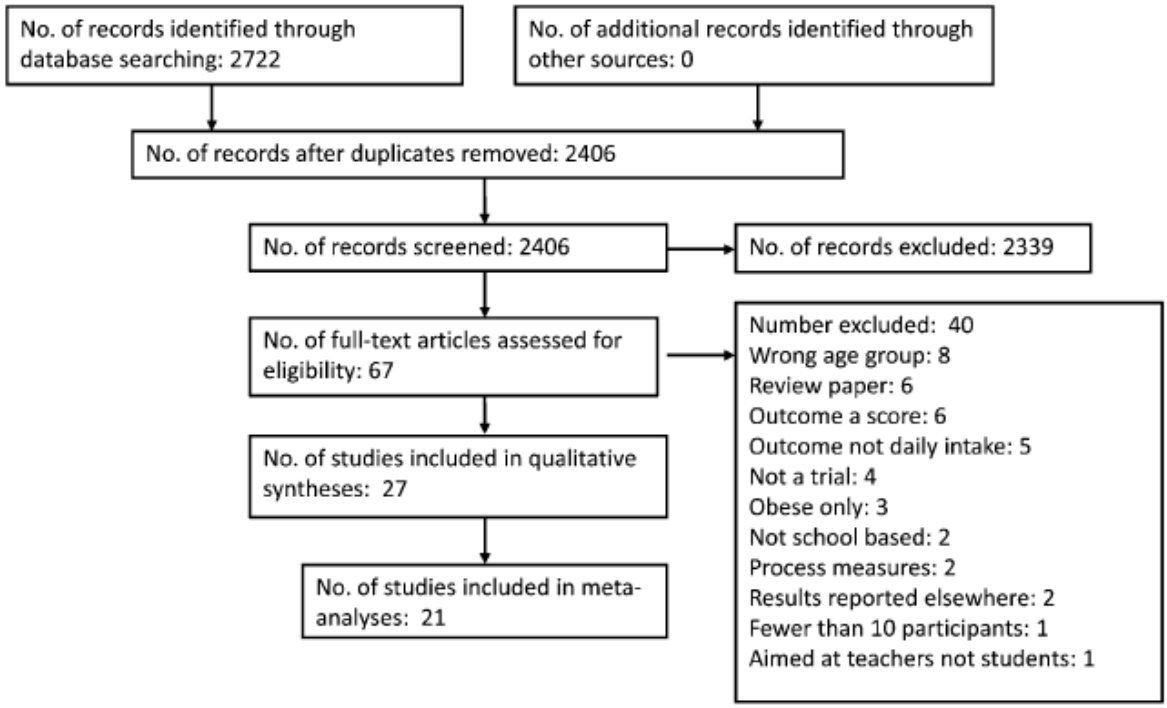

Figure 2: Pooled estimate of difference in daily intake of portions of fruit and vegetables (veg) between intervention and control groups; using longest follow up data available and excluding studies that combined fruit and fruit juice. Weight was assigned using STATA version 11 using n and SEM. Horizontal lines denote 95% CIs. The diamond represents the overall estimated effect. The meta-analysis used the weighted mean difference in the random-effects model.

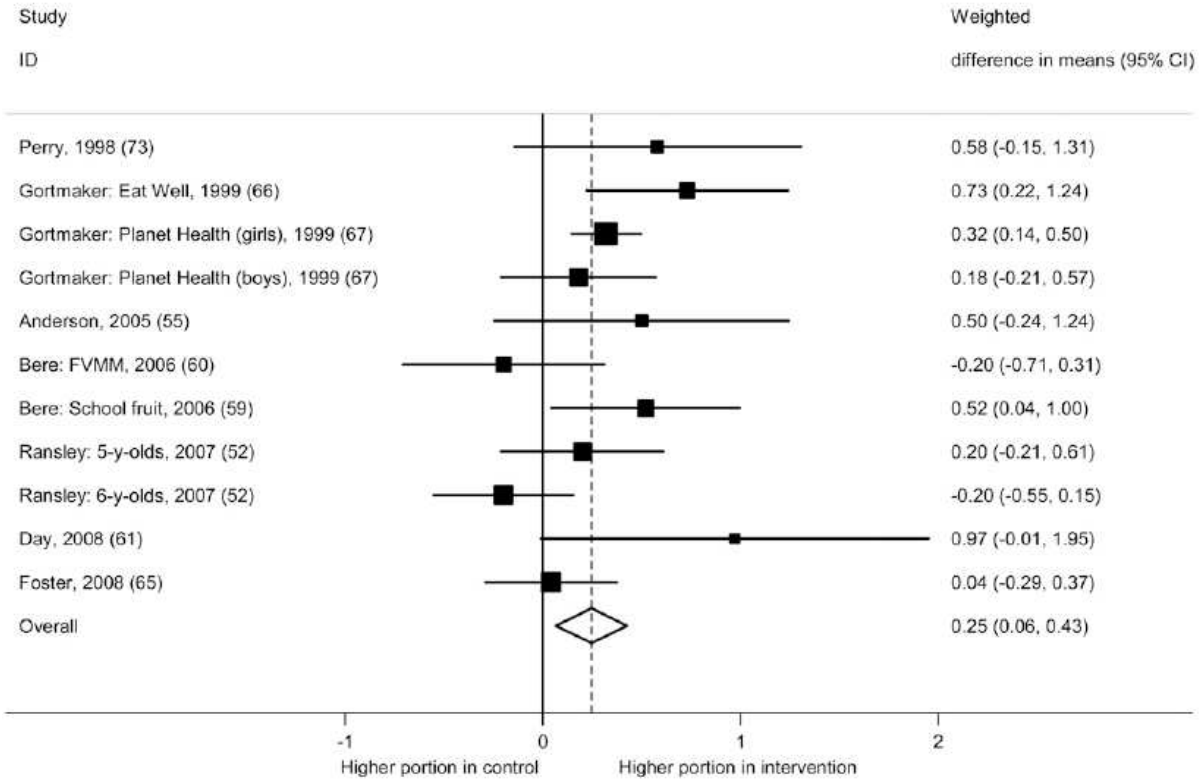

Figure 3: Pooled estimate of difference in daily portions of fruit and vegetables (veg) consumed between intervention and control group; using longest follow up data available and including studies that combined fruit and fruit juice. Weight was assigned using STATA version 11 using n and SEM. Horizontal lines denote 95% CIs. The diamond represents the overall estimated effect. The meta-analysis used the weighted mean difference in the random-effects model.

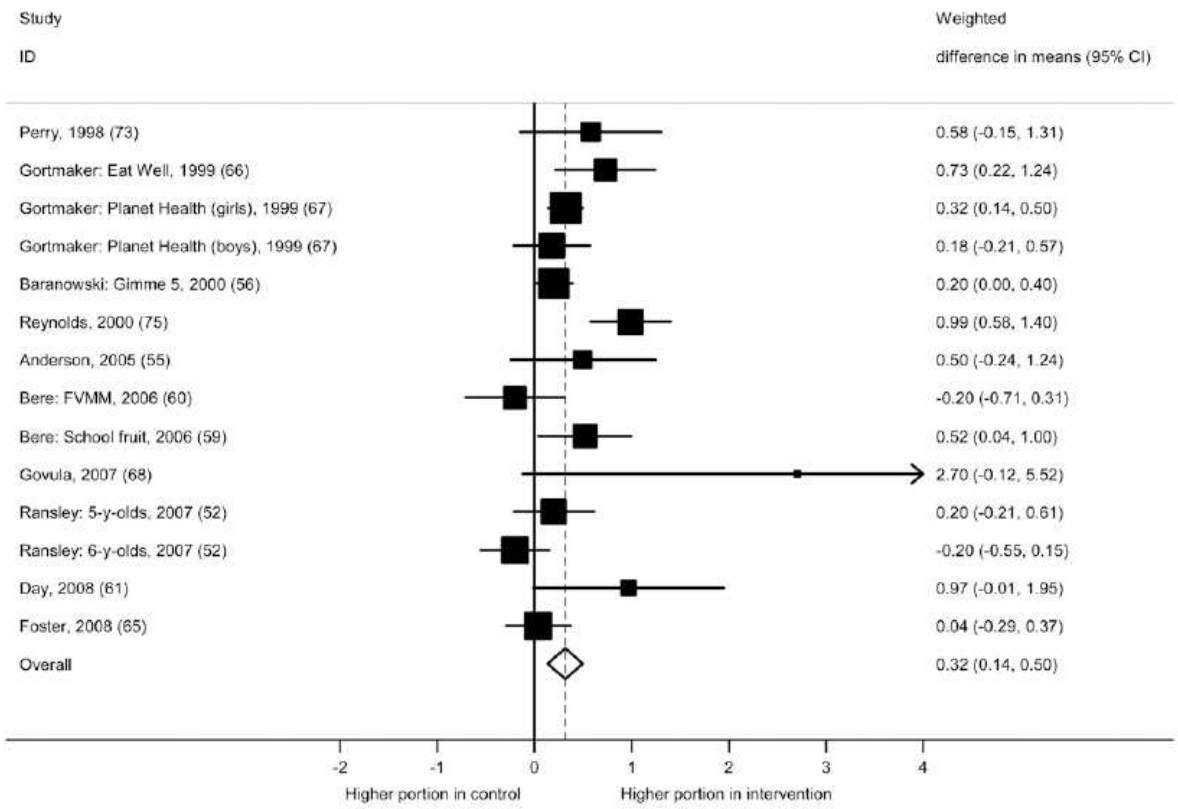

Figure 4: Pooled estimate of difference in daily portions of fruit consumed between intervention and control group; using longest follow up data available and excluding studies that combined fruit and fruit juice. Weight was assigned using STATA version 11 using n and SEM. Horizontal lines denote 95% CIs. The diamond represents the overall estimated effect. The meta-analysis used the weighted mean difference in the random-effects model.

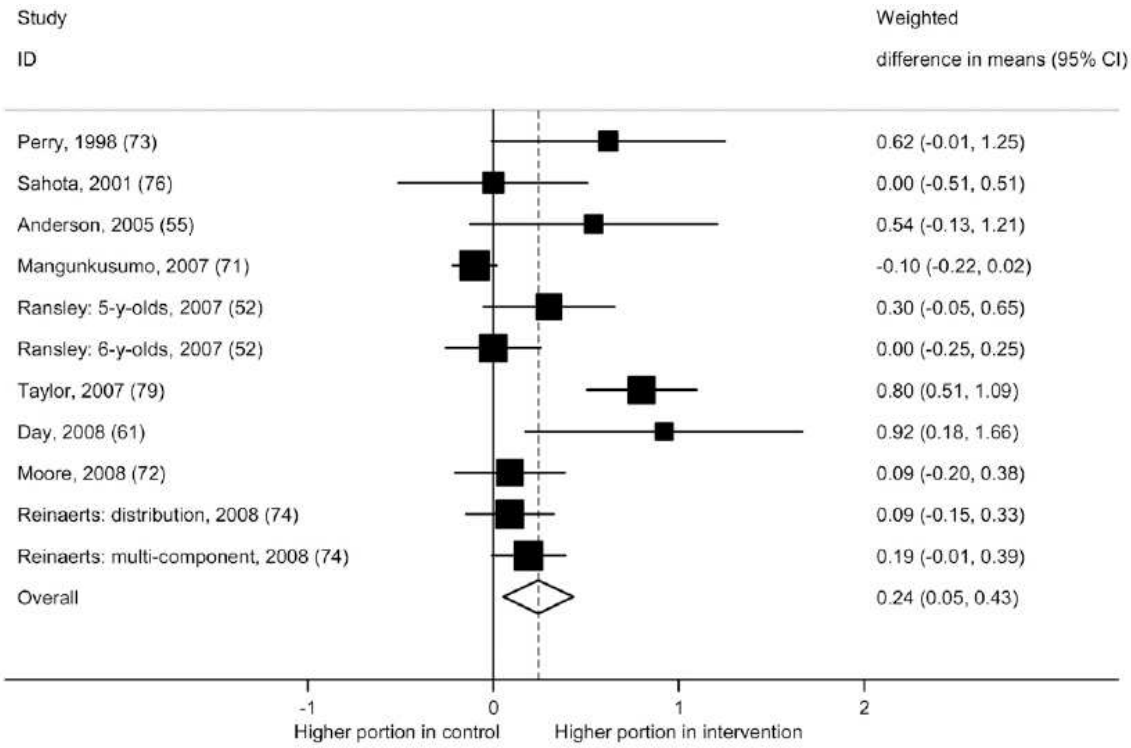

Figure 5: Pooled estimate of difference in daily portions of vegetables (veg) consumed between intervention and control group; using longest follow up data available and including studies that combined fruit and fruit juice. Weight was assigned using STATA version 11 using n and SEM. Horizontal lines denote 95% CIs. The diamond represents the overall estimated effect. The meta-analysis used the weighted mean difference in the random-effects model.