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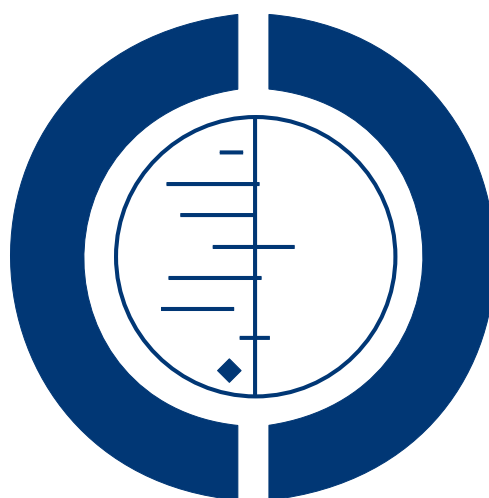
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Lifestyle intervention for improving school achievement in overweight or obese children and adolescents (Review)

Martin A, Saunders DH, Shenkin SD, Sproule J



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[Intervention Review]

Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

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ABSTRACT

Background

The prevalence of overweight and obesity in childhood and adolescence is high. Excessive body fat at a young age is likely to persist into adulthood and is associated with physical and psychosocial co-morbidities, as well as lower cognitive, school and later life achievement. Lifestyle changes, including reduced caloric intake, decreased sedentary behaviour and increased physical activity, are recommended for prevention and treatment of child and adolescent obesity. Evidence suggests that lifestyle interventions can benefit cognitive function and school achievement in children of normal weight. Similar beneficial effects may be seen in overweight or obese children and adolescents.

Objectives

To assess whether lifestyle interventions (in the areas of diet, physical activity, sedentary behaviour and behavioural therapy) improve school achievement, cognitive function and future success in overweight or obese children and adolescents compared with standard care, waiting list control, no treatment or attention control.

Search methods

We searched the following databases in May 2013: CENTRAL, MEDLINE, EMBASE, CINAHL Plus, PsycINFO, ERIC, IBSS, Cochrane Database of Systematic Reviews, DARE, ISI Conference Proceedings Citation Index, SPORTDiscus, Database on Obesity and Sedentary Behaviour Studies, Database of Promoting Health Effectiveness Reviews (DoPHER) and Database of Health Promotion Research. In addition, we searched the Network Digital Library of Theses and Dissertations (NDLTD), three trials registries and reference lists. We also contacted researchers in the field.

Selection criteria

We included (cluster) randomised and controlled clinical trials of lifestyle interventions for weight management in overweight or obese children three to 18 years of age. Studies in children with medical conditions known to affect weight status, school achievement and cognitive function were excluded.

Data collection and analysis

Two review authors independently selected studies, extracted data, assessed quality and risk of bias and cross-checked extracts to resolve discrepancies when required. Authors were contacted to obtain further study details and were asked to provide data on the overweight and obese study population when they were not reported separately.

Main results

Of 529 screened full-text articles, we included in the review six studies (14 articles) of 674 overweight and obese children and adolescents, comprising four studies with multicomponent lifestyle interventions and two studies with physical activity only interventions. We conducted a meta-analysis when possible and a sensitivity analysis to consider the impact of cluster-randomised controlled trials and/or studies at 'high risk' of attrition bias on the intervention effect. We prioritised reporting of the sensitivity analysis when risk of bias and differences in intervention type and duration were suspected to have influenced the findings substantially. Analysis of a single study indicated that school-based healthy lifestyle education combined with nutrition interventions can produce small improvements in overall school achievement (mean difference (MD) 1.78 points on a scale of zero to 100, 95% confidence interval (CI) 0.8 to 2.76; $P < 0.001$; $N = 321$; moderate-quality evidence). Single component physical activity interventions produced small improvements in mathematics achievement (MD 3.00 points on a scale of zero to 200, 95% CI 0.78 to 5.22; P value = 0.008; one RCT; $N = 96$; high-quality evidence), executive function (MD 3.00, scale mean 100, standard deviation (SD) 15, 95% CI 0.09 to 5.91; P value = 0.04; one RCT; $N = 116$) and working memory (MD 3.00, scale mean 100, SD 15, 95% CI 0.51 to 5.49; P value = 0.02; one RCT; $N = 116$). No evidence suggested an effect of any lifestyle intervention on reading, vocabulary and language achievements, attention, inhibitory control and simultaneous processing. Pooling of data in meta-analyses was restricted by variations in study design. Heterogeneity was present within some meta-analyses and may have been explained by differences in types of interventions. Risk of bias was low for most assessed items; however in half of the studies, risk of bias was detected for attrition, participant selection and blinding. No study provided evidence of the effect of lifestyle interventions on future success. Whether changes in academic and cognitive abilities were connected to changes in body weight status was unclear because of conflicting findings and variations in study design.

Authors' conclusions

Despite the large number of childhood obesity treatment trials, evidence regarding their impact on school achievement and cognitive abilities is lacking. Existing studies have a range of methodological issues affecting the quality of evidence. Multicomponent interventions targeting physical activity and healthy diet could benefit general school achievement, whereas a physical activity intervention delivered for childhood weight management could benefit mathematics achievement, executive function and working memory. Although the effects are small, a very large number of children and adolescents could benefit from these interventions. Therefore health policy makers may wish to consider these potential additional benefits when promoting physical activity and healthy eating in schools. Future obesity treatment trials are needed to examine overweight or obese children and adolescents and to report academic and cognitive as well as physical outcomes.

PLAIN LANGUAGE SUMMARY

Lifestyle interventions for improving school achievement in overweight or obese children and adolescents

Many children and adolescents worldwide are overweight or obese. Children and adolescents who are overweight or obese have increased physical disease and emotional distress. They also perform less well on tests of thinking (cognitive ability), and they do less well in school. To prevent and treat obesity, several lifestyle changes have been suggested, for example, being more physically active, eating fewer calories and sitting less. These interventions are known to improve thinking skills and school achievement in children of normal weight. It is unknown whether the effects are the same in overweight or obese children and adolescents.

The review authors searched for studies that evaluated school achievement, cognitive ability and later life achievement (e.g. income, employment) in overweight or obese children and adolescents randomly assigned to a lifestyle intervention (aiming to be more physically active and/or improving diet and/or sitting less) or a control condition (e.g. standard care, no treatment). We found six relevant studies with a total of 674 overweight and obese children.

We found that, compared with standard school routine, school-based interventions targeting healthy diet and lifestyle education led to small improvements in overall school achievement in overweight or obese children. We also found that increasing physical activity improved scores on tests of mathematics and memory, and improved 'problem-solving' thinking skills. No clear evidence was found

of an effect on other thinking skills related to reading, language or vocabulary. We found no studies that looked at whether lifestyle interventions affected achievements after leaving school.

Overall, despite the large number of childhood obesity treatment studies, only a select few evaluated the effects of obesity treatment on school achievement and cognitive function. The existing studies are limited in quality but suggest that lifestyle interventions could benefit overweight and obese children specifically in overall school achievement, mathematics, memory and specific thinking skills. Health policy makers may wish to consider these potential additional benefits when promoting physical activity and healthy eating in schools. Future obesity treatment studies could consider academic and cognitive as well as physical outcomes.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Lifestyle interventions versus standard care for improving school achievement in overweight or obese children and adolescents						
Patient or population: overweight or obese children and adolescents Settings: overweight or obese child and youth population Intervention: lifestyle intervention Comparison: standard care						
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Standard care	Lifestyle intervention				
Overall school achievement Grade point average obtained from school records Scale from zero to 100 Follow-up: mean two years	Mean overall school achievement in the control groups was -2.64 average points	Mean overall school achievement in the intervention groups was 1.78 higher (0.8 to 2.76 higher)		321 (one study ¹)	⊕⊕⊕○ moderate ²	
Mathematics achievement Woodcock-Johnson Tests of Achievement III Scale from zero to 200 Follow-up: mean 13 weeks	Mean mathematics achievement in the control groups was 104 points	Mean mathematics achievement in the intervention groups was three higher (0.78 to 5.22 higher)		96 (one study ¹)	⊕⊕⊕⊕ high	
Language achievement CAT-3-Canadian Achievement Test, version 3 Scale from zero to 1000	Mean language achievement in the control groups was 583.67 points	Mean language achievement in the intervention groups was 27.97 higher (5.35 lower to 61.29)		73 (one study)	⊕○○○ very low ^{2,3,4}	

Follow-up: mean one year		higher)				
Reading achievement Woodcock-Johnson Tests of Achievement III Follow-up: mean 13 weeks	Mean reading achievement in the control groups was 100 points	Mean reading achievement in the intervention groups was 0.0 higher (2.21 lower to 2.21 higher)		96 (one study)	⊕⊕⊕⊕ high	
Writing achievement	Study population		Not estimable	zero (zero)	See comment	No evidence available
	See comment	See comment				
	Moderate					
Vocabulary achievement Peabody Picture Vocabulary Test, version 3 Scale from zero to 200 Follow-up: mean 24 weeks	Mean vocabulary achievement in the control groups was 84.17 points	Mean vocabulary achievement in the intervention groups was 1.19 higher (4.04 lower to 6.42 higher)		80 (one study)	⊕⊕○○ low ^{2,4}	
Special education class	Study population		Not estimable	zero (zero)	See comment	No evidence available
	See comment	See comment				
	Moderate					

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio.

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

¹ Findings are presented after a sensitivity analysis has been carried out. High risk of bias and differences in intervention type and duration were suspected to have influenced the finding substantially; thus findings of the sensitivity analysis are presented in this table.

² Intervention was aimed at the general population (normal weight and overweight/obese), not at overweight/obese children only.

³ Study had a high risk of attrition bias.

⁴ Study included only a few participants, which resulted in a wide confidence interval.

BACKGROUND

Description of the condition

Overweight and obesity are conditions of excessive body fat accumulation. In clinical practice, paediatric overweight and obesity are commonly identified by age- and gender-specific body mass index (BMI) percentiles, BMI standard deviation scores, BMI cut-offs and waist circumference (WC) percentiles relative to a reference population (Reilly 2010; Rolland-Cachera 2011).

The primary criteria used to define overweight and obesity include:

1. overweight: BMI or WC \geq 85th percentile to 95th percentile, BMI $>$ +one standard deviation of the average; and
2. obesity: BMI or WC $>$ 95th percentile, BMI $>$ +two standard deviations of the average.

Also, BMI cutoffs from the International Obesity Task Force (IOTF) are often used as a definition of overweight and obesity. These age-specific BMI cutoffs were constructed to match the definition of overweight and obesity in adults (BMI \geq 25 kg/m² and BMI \geq 30 kg/m², respectively) (Cole 2000). Recently, the IOTF BMI cutoffs were reformulated to allow BMI to be expressed as standard deviation or percentile (Cole 2012).

These criteria are used to define overweight and obesity in this review.

In 2010, the World Health Organization (WHO) estimated that more than 40 million children younger than five years of age were overweight worldwide (WHO 2012). In the USA, the prevalence of overweight and obese children and adolescents (aged two to 19 years) was 32% (Ogden 2010). Results of UK surveys indicate that 33% of children in their final year of primary school are overweight or obese (NHS 2010). Childhood obesity prevalence is increasing in middle- and low-income countries, for example, up to 40% of children in Mexico are overweight and obese, 32% in Lebanon and 28% in Argentina (Gupta 2012).

Childhood obesity is associated with adverse health consequences, including atherosclerosis, hypertension, type 2 diabetes, fatty liver disease and the metabolic syndrome (Calcaterra 2008; Daniels 2009). Co-morbid health problems are common in obese children and include psychosocial disorders (e.g. depression, anxiety), respiratory disorders (e.g. obstructive sleep apnoea) and skeletal disorders (e.g. musculoskeletal discomfort) (Han 2010; Puder 2010). Interest is growing in the connection between increased body fatness and children's brain health, cognitive function and related attainments such as educational achievement and future socioeconomic success (Geddes 2010).

In terms of cognitive function, evidence from systematic reviews and meta-analyses indicates that overweight or obese children of primary school age have a significantly lower full intelligence quotient (IQ) (eight studies; N = 1086) and performance IQ (four studies; N = 536) compared with children of normal weight (Yu 2010). A recent systematic review, which included observational studies of children and adolescents up to 18 years of age, con-

cluded that consistent evidence suggests a negative association between overweight or obesity and executive function, attention and visuospatial skills (39 studies; N = 16,112), that is, overweight or obese children score less well on some cognitive tests (Liang 2013).

In terms of school achievement, a systematic review of cross-sectional and longitudinal studies (29 studies; study population ranged from N = 259 to N = 60,252) concluded that childhood obesity is weakly associated with lower educational achievement (Caird 2011). However, this association was further weakened when confounding variables such as socioeconomic status were controlled. Findings of a prospective cohort study (N = 2582, follow-up six years) indicate that 'growing out of obesity' was associated with improved mathematics achievement after adjustments for confounding variables compared with maintaining normal body weight status (Carter 2010). This finding suggests that interventions for reducing child and youth obesity may have beneficial effects on school achievement.

In terms of future 'success', a Finnish longitudinal study (N = 9754, follow-up 17 years) suggested that adolescent obesity predicts unemployment in later life, with educational achievement as a mediating factor (Laitinen 2002). A British birth cohort study (N = 12,537) indicated that adolescent obesity (at age 16 years) is associated with fewer years of schooling and predicts lower income in young female adults (at age 23 years), including those who are no longer obese (Sargent 1994). These findings were further confirmed by Han 2011, using the National Longitudinal Survey of Youth 1979 (N = 1974, follow-up 12 to 16 years), and by Sabia 2012, using the National Longitudinal Study of Adolescent Health (N = 12,445, follow-up 13 years). Findings from the National Longitudinal Survey of Youth 1997 (N = 8427, follow-up eight years) suggest that obese adolescents had a 39% lower chance of obtaining a college degree than peers of normal weight (Fowler-Brown 2010). All of these studies accounted for a variety of confounding variables, including measures of socioeconomic status (e.g. parental education, household income).

These sources of evidence are based on observational data. This suggests that data are vulnerable to confounding even when some confounders are measured and accounted for; it also suggests that causal effects cannot be inferred. Reverse causation is possible, whereby children with poorer baseline cognitive ability or educational achievement are more likely to be obese. However, these data do allow one to hypothesise that interventions that reduce body weight might provide a range of additional benefits.

Description of the intervention

A lifestyle intervention aims to modify individuals' way of living and improve their health by changing patterns of behaviour that are harmful to health (WHO 1998). A lifestyle intervention for obese people targets dietary patterns, physical activity, sedentary behaviour and behaviour patterns. Clinical guidelines for prevention and treatment of childhood obesity from countries such as

the UK (NICE 2013; SIGN 2010), Australia (NHMRC 2003), Canada (Lau 2007) and Malaysia (Ismail 2004) recommend a multicomponent approach that combines:

1. reduced energy intake;
2. increased physical activity (≥ 60 minutes/d, moderate to vigorous intensity);
3. decreased sedentary behaviour (e.g. screen time less than two hours/d); and
4. behaviour change techniques (e.g. goal setting, self monitoring, self regulation).

A Cochrane review concluded that lifestyle interventions aiming to alter eating habits, sedentary behaviour and physical activity patterns in a family-based setting were effective in achieving clinically meaningful weight reduction in children (Oude Luttikhuis 2009).

How the intervention might work

Effects in the general child and adolescent population

Multicomponent lifestyle interventions may benefit cognitive function and school achievement in the general population, that is, a study population that includes both children and adolescents of normal weight and those who are overweight or obese. For example, after implementation of an uncontrolled intervention involving healthy nutrition, physical activity and behaviour change techniques in a US primary school, an upward trend in reading performance scores was noted; these scores exceeded the national average by 10% after eight years (Nansel 2009). Another uncontrolled study implementing a healthy diet and physical activity programme in a primary school reported an increase in the numbers of children passing standardised tests in writing, reading and mathematics by 25%, 27% and 31%, respectively (Sibley 2008). A similar but controlled school-based intervention promoting healthy eating and physical activity behaviour in children 11 to 14 years of age led to significant improvement in mathematics, listening and speaking scores after only five weeks compared with the control condition (standard classroom education) (Shilts 2009).

Aspects of lifestyle interventions

Dietary modification

Composition of the diet may impact cognition and educational achievement by altering neurotrophic and neuroendocrine factors involved in learning and memory. These are decreased by high-energy diets containing saturated fat and simple sugars, and they are increased by diets that are rich in omega-3 polyunsaturated fatty acids and micronutrients (Gomez-Pinilla 2008; Kanoski 2011). Longitudinal data suggest that diets high in fat and sugar in

preschool children (N = 3966; age three to four years) are associated with decreased intelligence and school performance at primary school age (Feinstein 2008; Northstone 2011). A controlled healthy school meal intervention over three years in more than 80,000 children led to improved mathematics, English and science achievement (Belot 2011). Therefore, an improvement in dietary quality could have beneficial effects even without weight loss.

Increased physical activity

Physical activity may affect cognitive function and academic achievement through physiological mechanisms (elevated blood circulation, increased levels of neurotrophins and neurotransmitters) (Dishman 2006), learning and developmental mechanisms (children's movement experience stimulates the processing of other concepts) (Piaget 1956).

A meta-analysis of 44 experimental and cross-sectional studies (in children aged four to 18 years) indicated that increased physical activity caused significant overall improvement in cognitive function and school performance (effect size 0.32; standard deviation (SD) 0.27) (Sibley 2003). A systematic review suggests that school-based physical activity interventions (32 studies; N ~ 3762; in children five to 18 years of age) may enhance both cognitive and school performance (CDC 2010). Therefore, physical activity might also benefit overweight and obese children independent of weight loss.

Reduced sedentary behaviour

A sedentary lifestyle in children, particularly television viewing \geq two hours/d, is associated with the development of overweight or obesity (review of 71 studies; Rey-Lopez 2008) and may replace opportunities to engage in activities that promote scholastic and cognitive development. Longitudinal data indicate that children (younger than three years of age) with low television exposure ($<$ three hours/d) performed better than those with high television exposure (\geq three hours/d) in reading (N = 1031) and mathematics (N = 1797) (Peabody Individual Achievement Test) when at preschool age (Zimmerman 2005). Similarly, parent-reported television viewing in preschool children was inversely related to mathematics achievement at age 10 years (N = 1314) (Pagani 2010) and reading achievement at age 10 to 12 years (N = 308) (Ennemoser 2007). Longer-term educational outcomes may also be affected. Hancox 2005 indicated that young people (N = 980; follow-up 21 years) with the highest television viewing time during childhood and adolescence tended to have no formal educational qualifications, and those with a university degree watched the least television (TV) during childhood and adolescence. Television viewing \geq three hours/d at age 14 years (N = 678) was associated with a two-fold risk to fail to obtain a post-secondary school education at 33 years of age compared with those watching television $<$ one hour/d, mediated by attention difficulties, frequent failure to complete homework and negative attitudes about school at 16 years

of age (Johnson 2007). Therefore, reducing sedentary behaviour (TV and screen time, sitting time) in obese or overweight children might improve cognitive function and school achievement.

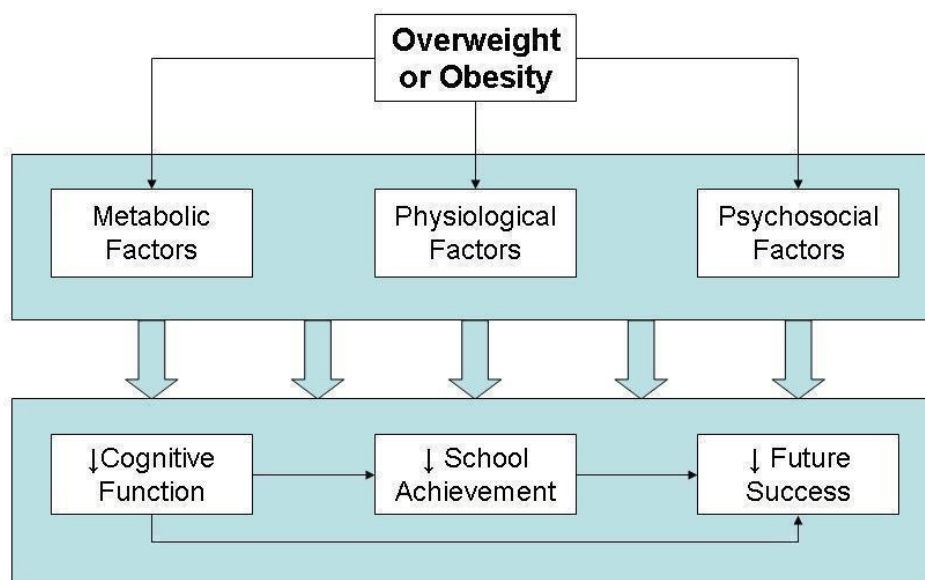
Behaviour modification

Behaviour change techniques in overweight and obese children may foster decision making and self control skills needed to increase energy expenditure and reduce energy intake (Bruce 2011); they also may benefit studying and thus educational achievement.

The effects of multicomponent lifestyle interventions or their individual components on cognitive function and school achievement might be influenced by study design characteristics (e.g. intervention type, dose and duration) and participant characteristics that determine physical and mental development and maturation (e.g. age, gender, weight status).

In summary, lifestyle interventions could act, alone or in combination, through numerous plausible mechanisms of action to benefit cognitive function, school achievement and future success (Figure 1).

Figure 1. Potential causal links between overweight or obesity and impaired cognitive function, school achievement and future success. Reverse causation may also occur when cognitive function, school achievement and future success can impact the 'mediating factors', and both in turn may cause worsening of overweight and obesity.



Effects in overweight and obese children and adolescents

Overweight and obesity are associated with poor cognitive function, school achievement and future success (Caird 2011; Sabia 2012; Sargent 1994; Yu 2010); therefore lifestyle interventions that reduce overweight and obesity (Oude Luttikhuis 2009) might

also benefit cognitive function and school achievement. Mechanisms explaining how lifestyle interventions could benefit overweight and obese children differently from the general population build on suggestive evidence from observational and experimental studies. These include neurocognitive, psychosocial and pathophysiological mechanisms associated with the development and consequences of childhood obesity.

Research indicates that overweight and obese children show higher impulsivity and inattention and lower reward sensitivity, self-regulation and mental flexibility compared with peers of normal weight (Delgado-Rico 2012a; Fields 2013; Nederkoorn 2006). These neurocognitive factors are associated with increased food intake and uncontrolled eating behaviour, and thus are assumed to be predictors of weight gain (Fields 2013; Francis 2009). Lifestyle interventions for weight management might positively impact the neurocognitive factors required for controlled food intake. A randomised controlled trial conducted in 44 overweight and obese children (eight to 14 years of age) suggested that specific training of self-regulatory abilities improved weight loss maintenance after an in-patient weight loss programme in the intervention group compared with the control group (Verbeken 2013). Findings from another randomised controlled overweight treatment programme involving 62 children (mean age 10.3 ± 1.1 years) showed improved problem-solving skills after an intervention duration of six months (Epstein 2000). Inhibition control skills were improved in 42 obese adolescents from 12 to 17 years of age after 12 weeks of cognitive-behavioural therapy (Delgado-Rico 2012b).

In comparison with normal weight children and youth, overweight and obese peers more often experience psychosocial distress through weight-related teasing, discrimination and social isolation; this can result in impaired self-esteem, self-efficacy and quality of life as well as depression (Brixval 2012; Danielsen 2012; Griffiths 2010; Puhl 2007). Overweight-related teasing and social rejection are associated with low school performance in overweight or obese children (Gunnarsdottir 2012a; Krukowski 2009). Psychosocial effects of overweight and obesity are suspected to mediate the inverse association between overweight and school performance (Caird 2011). Lifestyle interventions for paediatric overweight treatments might benefit school achievement through improvement of self-esteem, depressive symptoms and quality of life (Oude Luttikhuis 2009; Pratt 2013).

Child and youth obesity is associated with co-morbidities, such as hypertension, impaired insulin sensitivity and metabolic syndrome, which are known to be inversely related to cognitive function and academic achievement (i.e. children with hypertension, insulin resistance and metabolic syndrome have lower cognitive and academic test scores than those without these co-morbidities) (Lande 2012; Yau 2012). Health problems may also cause overweight and obese children to miss school more often (Pan 2013); higher levels of school absenteeism are associated with lower performance in school (Gottfried 2011). Research indicates that childhood obesity is also associated with sleep deprivation and

disrupted sleep due to obesity-related disordered breathing (Chen 2008; Spruyt 2012). Poor sleep may reduce the ability to concentrate in school (Beebe 2010) and impacts negatively on cognitive function and school achievement (Beebe 2010; Pérez-Chada 2009; Spruyt 2012). Lifestyle interventions can improve health and reduce co-morbidities in children (Oude Luttikhuis 2009), and thus may benefit cognitive and educational outcomes.

Lifestyle interventions for weight management could improve cognitive and school performance by reducing sources of metabolic and psychosocial stress, and by improving those neurocognitive abilities associated with weight gain. With increasing adiposity, the severity of neurocognitive, psychosocial and pathophysiological changes might increase, and the benefits of lifestyle interventions for weight management, as seen in school, cognitive and later life outcomes, might depend on the level of adiposity. Lifestyle interventions may benefit cognitive function, school and later life achievement through different obesity-related pathways (Figure 1); therefore it is plausible that overweight and obese children benefit more strongly than normal weight children from the effects of improved diet, physical activity and sedentary behaviour.

Why it is important to do this review

The current rising trend in childhood obesity (WHO 2012) means that the prevalence of cognitive and educational problems among children is also likely to increase. Given evidence of a link between low school achievement and economic disadvantage, this might have financial repercussions as regards future employability and income.

The beneficial effects of changes in diet, physical activity, sedentary behaviour and thinking patterns for prevention and treatment of childhood obesity are well established (Oude Luttikhuis 2009; Waters 2011) and are reflected in clinical guidelines for the management of obesity (Ismail 2004; Lau 2007; NHMRC 2003; NICE 2013; SIGN 2010). However, the extent to which these lifestyle interventions might affect cognitive function and subsequent school and later life achievement of overweight and obese children and adolescents remains unknown. Drawing from neurocognitive, psychosocial and pathophysiological aspects of causes and consequences of childhood obesity, lifestyle interventions for weight management might benefit overweight and obese children differently compared with normal weight children through modification of obesity-related conditions unlikely to be present in normal weight children (see [How the intervention might work](#)). It is important that researchers, as well as government agencies, educators and parents and guardians, work together to improve children's physical and mental health. This review is important, as it may influence the way in which existing health promotion policies for schools are monitored and evaluated. This review identified interventions most likely to yield benefits and assessed the likely extent of potential benefits. It may emphasise a reevaluation of policies and implementation of more effective interventions to improve the development, health and well-being of children and

adolescents.

OBJECTIVES

To assess whether lifestyle interventions (in the areas of diet, physical activity, sedentary behaviour and behavioural therapy) improve school achievement, cognitive function and future success in overweight or obese children and adolescents compared with standard care, waiting list control, no treatment or attention control.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs), cluster-randomised trials and controlled clinical trials (CCTs), with or without cross-over design, were eligible for inclusion. For inclusion of cross-over trials, data from the first iteration had to be obtainable.

Types of participants

Overweight or obese children and adolescents aged three to 18 years attending preschool or school, and whose body weight status was determined using age- and gender-specific BMI percentiles, BMI z-scores, BMI standard deviation scores (SDSs), BMI cut-off points or waist circumference. Classification of weight status needed to be based on a relevant national or international reference population for inclusion.

We did not exclude studies on the basis of location.

We excluded children with medical conditions known to affect weight status and academic achievement, such as Prader-Willi syndrome and diagnosed intellectual disabilities.

Types of interventions

Studies were eligible for inclusion when the interventions provided aimed to prevent or reduce childhood obesity. For inclusion, interventions had to be lifestyle interventions of any frequency and duration provided in any setting that comprised one or more of the following.

1. Interventions to increase physical activity (including exercise).
2. Dietary and nutritional interventions (excluding supplements).
3. Interventions to decrease sedentary behaviour, screen time and TV time.

4. Psychological interventions to facilitate weight management.

Interventions could target children with or without the participation of family members.

We excluded pharmacological and surgical interventions because these interventions are likely to be conducted in a less representative sample, thus limiting generalisability.

Eligible control interventions were waiting list, attention control, no treatment and standard care.

Types of outcome measures

Primary and secondary outcomes did not serve as criteria for selection of studies based on title and abstract. Assessment of outcome measures was a criterion for inclusion in this review when full texts were screened. We extracted outcome data at the end of the intervention and at any other follow-up time point.

Primary outcomes

1. School achievement (DoE 2010), recorded by appropriately trained investigators (e.g. teachers, researchers). Participant- and parent-reported data were excluded.

- i) Overall school performance.
 - a) Average of school subject performance over one academic year, for example, grade point average (GPA).
 - ii) Individual subject performances.
 - a) School participant percentage scores or standard achievement test scores for (a) math, (b) reading or (c) language.
 - b) Validated tests for school achievement in math, reading or language, for example, Woodcock-Johnson Tests of Achievement III.
 - iii) Special education classes.
 - a) Need for special education class.
 - b) Reduction of time allocated for special education class.

These primary outcomes were used for the 'Summary of findings' table.

Secondary outcomes

1. Cognitive function (Carroll 1993): measures of general cognitive ability or different cognitive domains (e.g. attention, memory, executive function) assessed using validated cognitive ability tests administered by appropriately trained investigators. We excluded participant-reported and parent-reported data.

2. Future success (Geddes 2010): includes, but is not limited to, total years of schooling, high school completion, enrolment in higher education, rates of full-time employment, monthly earnings, home ownership, receipt of social services obtained from administrative records and self reports.

3. Obesity indices: age- and gender-specific BMI, BMI z-scores and BMI-SDSs when obtained from measured (not self

reported) weight and height, measured waist circumference and measures of body fatness by dual-energy x-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA). Studies reporting obesity indices were included only when measures of school achievement, cognitive function and/or future success were also reported. Inclusion of these data might enable the review authors to examine whether any changes in school performance, cognitive function and/or future success variables occur independently of changes in obesity (see [How the intervention might work](#)). Inclusion of obesity indices was not intended to examine the effects of lifestyle interventions on childhood obesity itself because this has already been examined in another Cochrane Review ([Oude Luttikhuis 2009](#)).

Search methods for identification of studies

Electronic searches

We searched the following electronic databases in May 2013.

1. Cochrane Central Register of Controlled Trials (CENTRAL) 2013, Issue 4, part of The Cochrane Library.
 2. Ovid MEDLINE (1950 to Week 4 April 2013).
 3. EMBASE (1980 to Week 18 2013).
 4. PsycINFO (1806 to Week 5 April 2013).
 5. CINAHL Plus (1937 to current).
 6. MIT Cognet.
 7. ERIC (1966 to current).
 8. SPORTDiscus.
 9. IBSS - International Bibliography of Social Science (1951 to current).
 10. Conference Proceedings Citation Indexes (1990 to 3 May 2013).
 11. Cochrane Database of Systematic Reviews (CDSR) 2013, Issue 4, part of The Cochrane Library.
 12. Database of Reviews of Effectiveness (DARE) 2013, Issue 2, part of The Cochrane Library.
 13. Database on Obesity and Sedentary Behaviour Studies.
 14. Database of Promoting Health Effectiveness Reviews (DoPHER).
 15. Bibliomap-Database of Health Promotion Research.
 16. Trials Register of Promoting Health Interventions (TRoPHI).
 17. Current Controlled Trials ([controlled-trials.com](#)).
 18. WHO International Clinical Trial Registry ([who.int/trialsearch](#)).
 19. Networked Digital Library of Theses and Dissertations ([ndtld.org](#)).
- Search strategies are reported in [Appendix 1](#).

Searching other resources

We examined reference lists of systematic reviews and other reviews from *The Cochrane Library* and the EPPI-Centre, the bibliographies and citations of included studies and relevant guidelines to search for eligible studies.

We handsearched volumes one to seven of *The Journal of Human Capital*, which is not included in The Cochrane Collaboration handsearching list and is not comprehensively indexed by the databases we searched.

We contacted authors of included studies when outcome data were missing or further details on methodology were needed. Furthermore, authors were asked for new follow-up data that were not available when the study was published.

When necessary, we translated the title and abstract of non-English language studies. If the study appeared to be eligible for inclusion, we obtained the full article and a translation of the article for further assessment. Articles were translated from Chinese (Mandarin), Korean, Japanese, Spanish and German.

Data collection and analysis

Selection of studies

AM and DHS independently screened titles and abstracts to identify potentially relevant trials and assessed full reports for eligibility. We resolved different opinions about eligibility by discussion; when the review authors did not agree, the other review authors (SJS and JS) arbitrated. We recorded the reasons for excluding trials.

Data extraction and management

Two review authors (AM and DHS) independently extracted data using a predefined data extraction form. Cross-checking of extracts was performed to resolve discrepancies. The data extraction form included the following items.

1. General information: date of data extraction, review author ID, title, published or unpublished, study authors, year of publication, country, contact address, language of publication, source of study.
2. Eligibility criteria: study design, population, intervention, comparison.
3. Methods (including risk of bias assessment): study design, randomisation methods, allocation concealment, blinding, handling of missing data, selective data reporting.
4. Population: method and setting of recruitment; age, gender, ethnicity; inclusion and exclusion criteria; number of participants recruited, included and followed (total and in comparison groups); diagnostic criteria of cognitive function and overweight or obesity; comparability of groups at baseline; co-morbidities.

5. Intervention: type(s), frequency, mode of delivery, intensity of physical activity, methods and timing of comparison of intervention, setting, intervention and follow-up duration, who delivered intervention, attrition rates, assessment of compliance, details of comparison and control.

6. Outcome: assessor characteristics, baseline measures, measures immediately after intervention and at follow-up, follow-up time points, validity of measurement tools, definition of outcome (e.g. units, scales), primary outcome, secondary outcome.

7. Results: qualitative and quantitative data, continuous and dichotomous data, source, missing data, summary statistics for each group.

8. Analysis: statistical power, methods of analysis, adjustment for confounding.

Assessment of risk of bias in included studies

AM and DHS independently assessed the risk of bias in each trial using The Cochrane Collaboration tool for assessing risk of bias (Higgins 2011). Findings were cross-checked and discrepancies resolved through discussion. This included assessment of selection bias (random sequence allocation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment and incomplete outcome data), reporting bias (selective reporting) and other sources of bias. The review authors judged the risk of bias as 'high risk' of bias, 'low risk' of bias or 'unclear risk' of bias, using the information provided. We intended to resolve disagreements by discussion, and, if necessary, we planned to contact the other review authors (SJS and JS) to ask for advice. No disagreement between AM and DHS occurred.

Measures of treatment effect

We calculated or extracted the difference in mean values, that is, mean difference (MD), when continuous data, such as numerical marks, were measured on the same scale. When similar outcomes were measured on different scales, we calculated the standardised mean difference (SMD). When similar outcomes were measured on different scales but were reported as change data by one study and as postintervention data by another, we analysed the treatment effect by calculating the MD (Higgins 2011).

Included studies did not provide dichotomous or ordinal data. However, in Table 1, we describe how we intend to treat these types of data, if available.

Unit of analysis issues

Cluster-randomised trials

We scanned all included studies with clustered randomisation of participants for appropriate analysis of clustered data. For studies in which control of clustering was missing or insufficient, and individual participant data were not available, we approximately corrected the intervention effects of cluster-randomised trials by reducing the size of each trial to its 'effective sample size' (Higgins 2011). We planned to calculate the effective sample size in studies with dichotomous data presented as follows: number of participants and number of events divided by the 'design effect', which is $[1 + (M-1) * ICC]$, where M is the average cluster size and ICC is the intracluster correlation coefficient. When outcome measures were continuous, we divided the sample size by the design effect only. A sensitivity analysis was performed to determine the robustness of conclusions from meta-analyses that included cluster-randomised trials. When no ICC was reported, we used the ICC estimate of a similar study. Based on raw data from Ahamed 2007, the ICC of 0.019 was calculated and was used to estimate the effective sample size.

Cross-over trials

We considered cross-over trials as eligible for inclusion if participants were randomly assigned into the first period. We planned to include in the analysis only data from the first period, but none of the included studies were cross-over trials (see Table 1).

Multiple interventions per individual

We conducted subgroup analyses for studies that compared the effects of a single intervention (e.g. physical activity alone) versus a control condition separately from studies that compared a combination of any types and numbers of interventions of interest (e.g. physical activity with dietary advice) versus a control condition.

Multiple time points

We planned to analyse in a separate meta-analysis data from studies that reported results at more than one time point with comparable data of other studies at similar time points, but none of the included studies provided outcomes at multiple time points (see Table 1).

Dealing with missing data

When possible, we recorded characteristics of, reasons for and quantities of missing data for all included studies. We contacted trial authors to obtain missing data. In our analyses, we ignored data judged to be 'missing at random'. When possible, we imputed missing values in individual participant data using the last observation carried forward (LOCF) method. We performed sensitivity analyses to examine the effects of including imputed data in meta-analyses.

Assessment of heterogeneity

We assessed clinical heterogeneity by comparing the similarities of included studies in terms of participants, interventions (type, duration, mode of delivery, setting) and outcomes. By comparing study design and risk of bias, we evaluated methodological heterogeneity. We assessed statistical heterogeneity across studies by visual inspection of the forest plot, and we used the Chi² test with a significance level of $P < 0.1$ because of its low power in detecting heterogeneity when studies are low in sample size and numbers of events (Higgins 2011). In addition, we determined the percentage of variability of intervention effect due to statistical heterogeneity among studies by calculating the I² statistic. Variability greater than 50% may indicate moderate to substantial heterogeneity of intervention effects (Higgins 2011). Furthermore, we assessed the cause of heterogeneity by conducting subgroup and sensitivity analyses, as described below.

Assessment of reporting biases

We had planned to assess reporting bias by using funnel plots but were unable to do so because of insufficient numbers of included studies (see Table 1).

Data synthesis

We used Review Manager 5.2 (Review Manager 2011) for data entry and analysis. We combined outcome data from included studies in meta-analyses when the outcome measure addressed the same measurement concept (e.g. school achievement) and used the same measurement scale (e.g. grade point average). We planned to combine dichotomous and continuous data measuring the same outcome as recommended in Chapter 9 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011) but were unable to do so, as all data from included studies were continuous (see Table 1).

Lifestyle intervention studies have inherent heterogeneity due to intervention implementation and setting, so the true intervention effect is likely to vary between studies. Therefore, we pooled data using the random-effects model and provided effect sizes of studies that were inappropriate to include in a meta-analysis.

Subgroup analysis and investigation of heterogeneity

Subgroup analyses are principally intended to investigate sources of heterogeneity within a meta-analysis in relation to factors that potentially impact outcomes. We identified several potentially influential participant and intervention characteristics for subgroup

analyses (see Table 1). However, we performed only one subgroup analysis because of the low number of included studies; this analysis compared studies employing multicomponent versus single component interventions.

Sensitivity analysis

We investigated the influence of study characteristics on the robustness of the review results by conducting sensitivity analyses. We removed trials from the analysis when studies:

1. used different criteria or variations in the thresholds of criteria to define childhood overweight and obesity;
2. were judged at 'high risk' of bias in the characteristics of random sequence allocation, concealment of allocation, blinding and extent of dropouts;
3. were cluster RCTs or cross-over trials; and
4. required imputation of missing data.

RESULTS

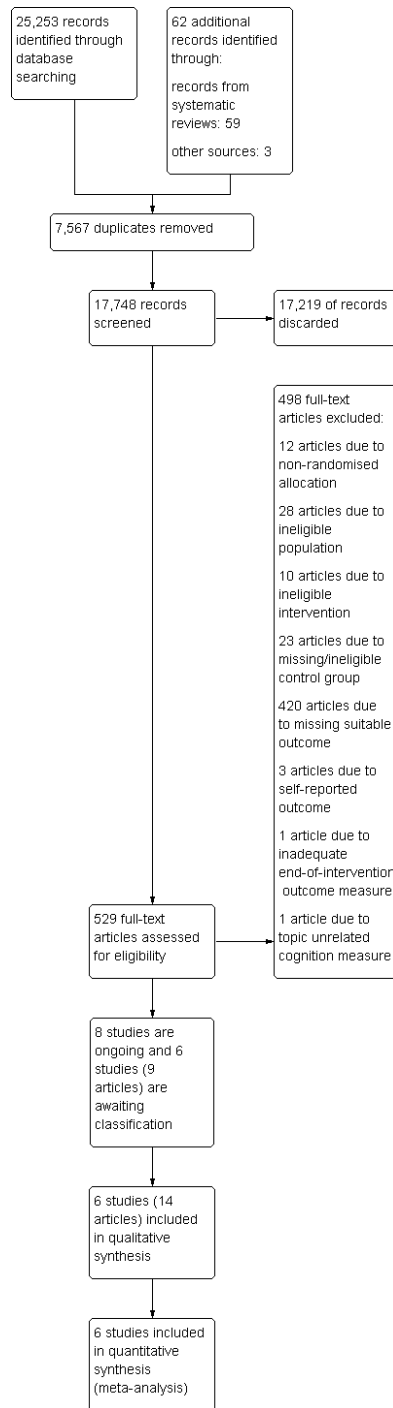
Description of studies

See [Characteristics of included studies](#); [Characteristics of excluded studies](#).

Results of the search

The literature search yielded 25,253 records, of which 7567 were duplicates. Sixty-two additional records were found primarily by screening the reference lists of relevant systematic reviews. Most of these additional records targeted the general population rather than the overweight/obesity population only, or were non-randomised controlled trials and therefore were not captured by the search strategy. We screened 17,748 titles and abstracts, and we excluded 17,219 records. Primary or secondary outcomes of this review should not determine whether records are excluded on the basis of title and abstract; therefore we retrieved 529 full-text articles, of which six studies (total sample size = 674) met the inclusion criteria (see [Characteristics of included studies](#)). An additional six studies are awaiting classification (see [Characteristics of studies awaiting classification](#)), and eight studies are ongoing (see [Ongoing studies](#)). A flow chart of the search results is shown in [Figure 2](#).

Figure 2. Study flow diagram.



Included studies

Study design, geographical location and setting

We included two randomised controlled trials (Davis 2011; Staiano 2012) and four cluster-randomised controlled trials (Ahamed 2007; Johnston 2013; Winter 2011; Wirt 2013). Of the six studies, four were conducted in the USA, one was carried out in Canada and one in Germany. Three studies took place in the classroom and/or within the school environment (Ahamed 2007; Johnston 2013; Staiano 2012); one study provided an after-school intervention outside the school setting (Davis 2011), and two studies delivered the intervention both in the classroom and in participants' homes (Winter 2011; Wirt 2013).

Population and sample size

Half of the included studies did not publish data of overweight and/or obese children separately from data of the general population; therefore we contacted the study authors to obtain the data. One study was carried out in preschool children three to five years of age (Winter 2011), four studies conducted the intervention in primary school children six to 13 years of age (Ahamed 2007; Davis 2011; Johnston 2013; Wirt 2013) and another study included adolescents 15 to 18 years of age (Staiano 2012). The numbers of participants randomly assigned ranged from 37 to 321 (total N = 792). The overall proportions of girls were 57% and 53% in Staiano 2012 and Wirt 2013, respectively. Proportions of girls in the intervention group were 54% (Davis 2011), 48% (Ahamed 2007), 38% (Johnston 2013) and 25% (Winter 2011), whereas proportions of girls in the control group were 62% (Davis 2011), 19% (Ahamed 2007), 46% (Johnston 2013) and 37% (Winter 2011). Ethnic majorities in the study populations were Black (Davis 2011; Staiano 2012), Hispanic (Johnston 2013; Winter 2011), Asian (Ahamed 2007) and South-East European (Wirt 2013). Attrition rates were 5.2% (Davis 2011), 21.0% (Johnston 2013), 24.3% (Wirt 2013), 27.0% (Staiano 2012), 27.5% (Winter 2011) and 29.1% (Ahamed 2007).

Interventions and comparisons

Four of the included studies involved multicomponent lifestyle interventions (Ahamed 2007; Johnston 2013; Winter 2011; Wirt 2013); the remaining two studies involved single component physical activity interventions. All interventions included engagement in physical activity; however, type, intensity, duration and frequency varied between studies. Types of physical activity ranged from aerobic physical activity group sessions (Ahamed 2007; Davis 2011; Wirt 2013) and general encouragement to increase physical activity throughout the day (Johnston 2013; Winter 2011) to playing an active video game ('exergaming') (Staiano 2012). Multicomponent interventions included, in addition to the physical activity component, a behavioural change intervention in the form of healthy lifestyle or nutrition education (Ahamed 2007;

Johnston 2013; Winter 2011; Wirt 2013) and dietary intervention (Ahamed 2007; Johnston 2013). Interventions lasted 10 to 13 weeks (Davis 2011; Staiano 2012), six months (Winter 2011), one school year (Ahamed 2007; Wirt 2013) and two school years (Johnston 2013). The comparison condition for all included studies was 'standard care', referring to usual physical activity and/or usual school curriculum, including physical education lessons. One study applied a waiting list control condition (Wirt 2013).

Outcomes

In all studies, outcomes were measured at baseline and immediately after the intervention period was completed. None of the studies performed further follow-up assessments. See Appendix 2 for a summary of the measurement tools used to assess primary and secondary outcomes.

1. School achievement.

School achievement was assessed for mathematics (Ahamed 2007; Davis 2011; Johnston 2013), vocabulary skills (Winter 2011), reading (Ahamed 2007; Davis 2011; Johnston 2013), English/language arts (Ahamed 2007) and science (Johnston 2013) using the Woodcock-Johnson Tests of Achievement III (Davis 2011), the Canadian Achievement Test (CAT)-3 (Ahamed 2007), the Peabody Picture Vocabulary Test III (Winter 2011) and local achievement assessment criteria (Johnston 2013). Of the four studies that assessed school achievement, two provided overall scores/grade point average (GPA) (Ahamed 2007; Johnston 2013). The remaining studies reported subject-specific scores. Although receptive vocabulary skills measured by the Peabody Picture Vocabulary Test are often used as measures of general intelligence, we classified these as school achievement outcomes because the trial authors intended to assess school readiness.

2. Cognitive function.

Four of the six included studies assessed cognitive function. Most studies measured specific cognitive domains rather than general intelligence. Two studies assessed executive function using the Das-Naglieri-Cognitive Assessment System (CAS) (Davis 2011) and the Delis-Kaplan Executive Function System (Staiano 2012); two further studies assessed attention using the Das-Naglieri-CAS (Davis 2011) and the KiTAP (Wirt 2013). Other cognitive domains included inhibitory control assessed by the KiTAP (Wirt 2013) and successive and simultaneous processing assessed by the Das-Naglieri-CAS (Davis 2011).

3. Future success.

None of the included studies assessed measures of future success.

Excluded studies

In total, 498 full-text articles were excluded. For 420 articles, primary and secondary outcomes of interest were not reported in the article. Further reasons for exclusion were non-randomised study

design (12 articles), ineligible population (28 articles), ineligible intervention (10 articles) and missing/ineligible control condition (23 articles). Articles were excluded when the age of the population did not fall into the age range of three to 18 years, or when studies did not focus on overweight or obese children. Ineligible interventions were considered to be those that did not aim to prevent or treat childhood overweight or obesity, for example, a behaviour change intervention to reduce teasing or health risk behaviours such as aggression. Lifestyle interventions that were too short in duration (e.g. a one-off session of 20 minutes of physical activity) were not suitable for weight management and thus were not eligible for inclusion. Three articles were excluded because of self reported outcomes, one article reported cognitive function scores related to appetite control rather than school achievement and one study provided an inadequate end-of-intervention outcome measure.

The number of excluded full-text screened studies was too high to list the reason for exclusion for each excluded study in [Characteristics of excluded studies](#); therefore we listed only those

lifestyle intervention studies that did not meet all inclusion criteria but:

1. intended to prevent or treat childhood overweight or obesity and reported measures of school achievement or cognitive function ([Delgado-Rico 2012b](#); [Gunnarsdottir 2012b](#); [Hollar 2010](#); [Hutson 2008](#); [Leidy 2013](#); [Milosis 2007](#); [Reed 2012](#); [Robinson 2010](#); [Vanhelst 2012](#); [Verbeken 2013](#); [Vos 2011](#)); and
2. reported measures of school achievement or cognitive function with a specific focus on overweight/obese children and adolescents without the primary intention to prevent or reduce obesity ([Bartholomew 2011](#); [Grieco 2009](#); [Hill 2011](#); [Tomporowski 2008](#)).

Risk of bias in included studies

The [Characteristics of included studies](#) table provides the reasons for the judgements of risk of bias for each bias item. [Figure 3](#) and [Figure 4](#) illustrate the judgement for each risk of bias item across all included studies and for each included study, respectively.

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

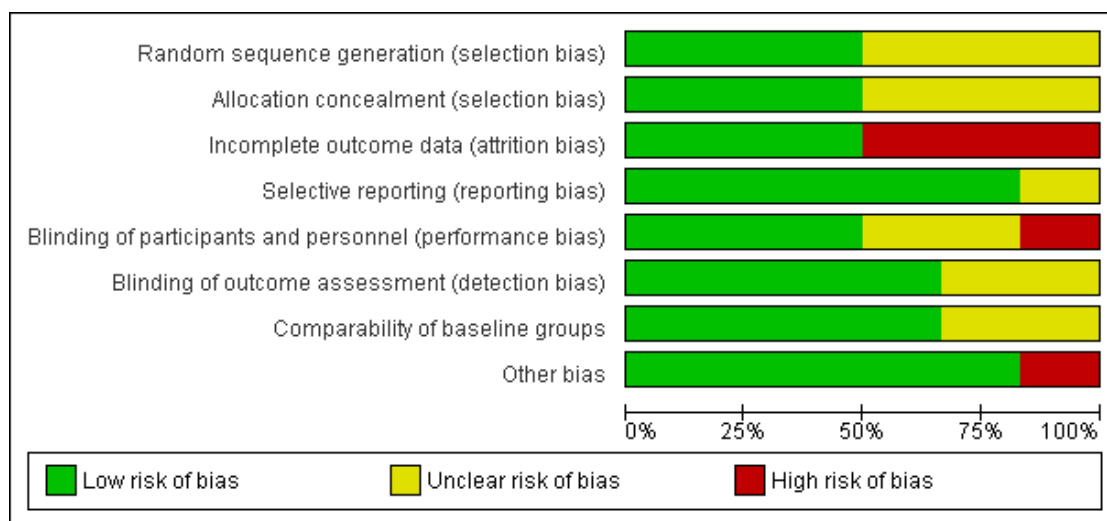


Figure 4. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Comparability of baseline groups	Other bias
Ahamed 2007	?	+	-	+	+	+	?	+
Davis 2011	+	+	+	+	+	+	+	+
Johnston 2013	+	?	+	?	?	?	+	+
Staiano 2012	?	?	-	+	+	+	+	-
Winter 2011	?	?	+	+	?	?	+	+
Wirt 2013	+	+	-	+	-	+	?	+

Allocation

Random sequence generation. Three studies were judged to be at unclear risk of bias (Ahamed 2007; Staiano 2012; Winter 2011) and three studies were judged to be at low risk of bias for random sequence generation (Davis 2011; Johnston 2013; Wirt 2013).

The difference in gender proportion across experimental groups in Ahamed 2007 may indicate a high risk of bias for randomisation. However, differences in the proportions of overweight girls across groups can be explained by a cluster effect and lack of stratified randomisation by gender. Data used for this review were obtained only from a subgroup of the total study population (i.e. overweight and obese children). The gender distribution between intervention and control schools for the entire study population is fairly equal (intervention group 50.7% girls, control group 47.4% girls). It is unclear why the proportion of overweight girls is substantially lower in the control group than in the intervention group; this could have occurred by chance. Nevertheless, the comparability of baseline groups might be at risk of bias (see [Other potential sources of bias](#)).

Allocation concealment. Of the six included studies, the risk of bias for allocation concealment was judged as unclear for three studies (Johnston 2013; Staiano 2012; Winter 2011) and low for three studies (Ahamed 2007; Davis 2011; Wirt 2013).

Blinding

Participants and personnel. True blinding of participants and personnel involved in delivering the intervention is not possible in a lifestyle intervention study. However, three studies (Ahamed 2007; Davis 2011; Staiano 2012) blinded participants and personnel to the true purpose of the study and therefore were judged to be at low risk for performance bias. Two studies were judged to be at unclear risk for performance bias (Johnston 2013; Winter 2011). Wirt 2013 was judged to be at high risk for performance bias because the personnel (teachers) were not blinded, although participants were blinded to the true purpose of the study.

Outcome assessment. The risk of bias for blinding of outcome assessment was judged to be unclear for two studies (Johnston 2013; Winter 2011) and low for four studies (Ahamed 2007; Davis 2011; Staiano 2012; Wirt 2013).

Incomplete outcome data

Of the six included studies, the risk for attrition bias was judged to be low in three studies (Davis 2011; Johnston 2013; Winter 2011) but high in three studies (Ahamed 2007; Staiano 2012; Wirt 2013) in which no imputation of missing data was performed. The study authors provided the reasons for attrition (see [Characteristics of included studies](#)). Attrition rates for studies judged to be at high risk were as follows.

1. Ahamed 2007: 29.1%, with 16.6% higher attrition in the intervention group than in the control group (intervention arm 26 of 78 children, control arm four of 25 children).

2. Staiano 2012: 27%, with 16.3% and 13.8% higher attrition in the the two interventions arms than in the control group (competitive intervention condition nine of 19 children, cooperative intervention condition eight of 19 children, control arm three of 19 children).

3. Wirt 2013: 24.3% (10 of 37 children). No group-specific data were available on different attrition rates at the child level. Instead, cluster-level data refer to the whole study population rather than to overweight and obese children only.

Reasons for higher attrition in intervention groups compared with the control group in Staiano 2012 could be intervention related, such as the reported reason that self consciousness due to obesity was increased by taking part in the intervention or lack of interest. Other reported reasons, such as school transfer or pregnancy, are less likely to be attributable to taking part in the intervention. Similar intervention-related effects might be the reason for higher attrition in the intervention group in Ahamed 2007. However, as this study is a cluster-RCT, reasons for higher attrition in intervention schools than control schools might be associated with the schools themselves rather than with the interventions. Ahamed 2007 reported that proportionately more children from intervention schools moved or were absent on the day of testing compared with children from control schools. Wirt 2013 reported that dropout occurred only at a school or class level, and that attrition was double for classes in the control group (two classes) compared with the intervention group (one class). The reasons for missing data are described in [Characteristics of included studies](#).

Selective reporting

The risk for selective reporting was judged to be low in five studies (Ahamed 2007; Davis 2011; Staiano 2012; Winter 2011; Wirt 2013) and unclear in the remaining study (Johnston 2013).

Other potential sources of bias

Two additional potential biases were detected.

1. Comparability of baseline groups might be a potential source of bias in cluster-RCTs (four studies). Two cluster-RCTs were free of this source of bias (Johnston 2013; Winter 2011). Two studies were judged to be at unclear risk of bias (Ahamed 2007; Wirt 2013).

2. Body weight alone is an unreliable measure of obesity and hence is at risk of measurement bias. One study was judged to be at high risk of measurement bias for measurement of obesity (Staiano 2012). The remaining studies were free of this potential

source of bias because obesity status was assessed using established age- and gender-specific BMI cutoffs.

Effects of interventions

See: [Summary of findings for the main comparison Lifestyle interventions versus standard care for improving school achievement-Findings after sensitivity analysis](#); [Summary of findings 2 Lifestyle interventions versus standard care for improving school achievement-Findings before sensitivity analysis](#)

Primary outcomes

The limited number of included studies restricts the usefulness of meta-analyses. Therefore, we present the findings on school achievement for each study separately. When possible, we determined the statistical heterogeneity of studies using similar methodology. For studies that did not take cluster-randomisation into account ([Ahamed 2007](#); [Winter 2011](#)), we corrected the numbers of participants for cluster-randomisation by calculating the effective sample size (see [Unit of analysis issues](#)). No subgroup analysis was performed because of the low number of included studies. For a summary of the effects of lifestyle interventions on primary outcomes, see [Summary of findings for the main comparison](#) and [Summary of findings 2](#). We have prioritised reporting of the sensitivity analysis when risk of bias and differences in intervention types and duration were suspected to have influenced the findings substantially ([Summary of findings for the main comparison](#)).

1. Overall school achievement

Two studies provided pre/postintervention change data on the effects of school-based, multicomponent lifestyle interventions on overall achievement for overweight and obese children in the subjects of mathematics, reading, language ([Ahamed 2007](#) only) and science ([Johnston 2013](#) only).

[Johnston 2013](#) tested the effects of healthy lifestyle education and nutrition interventions on GPA scores in 321 overweight and obese children seven to nine years of age. Findings indicate an MD of 1.78 points (95% confidence interval (CI) 0.8 to 2.76; $P < 0.001$) on a scale of zero to 100 favouring the intervention group. [Ahamed 2007](#) described the findings of 'Action Schools! BC', an intervention focused on increasing the physical activity and fruit and vegetable intake of children seven to 11 years of age. Intervention effects on average school achievement, measured using the CAT-3 in 64 overweight and obese children, suggested a non-significant beneficial effect in the control group (MD -16.53, 95% CI -86.63 to 53.57; P value = 0.64; scale mean score 500; scale SD 70).

The two studies were combined in a meta-analysis. Although similar in terms of age groups, intervention modes and outcomes, a high level of statistical heterogeneity (I^2) was noted. This could

be explained by differences in intervention dose. The intervention duration in [Johnston 2013](#) was two years, which is double the dose of the study by [Ahamed 2007](#). Risk of bias assessment suggests a high risk of attrition bias in [Ahamed 2007](#), whereas for [Johnston 2013](#), information for most risk of bias items was not obtainable; therefore risk was assessed as 'unclear'. Because different assessment scales were used, the SMD of change scores in school achievement between intervention and control groups was calculated (SMD 0.19, 95% CI -0.36 to 0.75; P value = 0.5; $I^2 = 73\%$) ([Analysis 1.1](#)). The combined results suggest no significant benefit of multicomponent lifestyle interventions for overall school achievement in overweight and obese primary school-aged children.

2. Subject-specific achievement

2.1 Mathematics achievement

The effects of lifestyle interventions on mathematics achievement were assessed in two studies. One study was a single component study employing an after-school, aerobic physical activity intervention ([Davis 2011](#)), and one study was a multicomponent intervention study ([Ahamed 2007](#)). These studies differed in the test tool used to assess mathematics achievement; [Davis 2011](#) applied the Woodcock-Johnson Tests of Achievement III, whereas [Ahamed 2007](#) used the Canadian Achievement Test-3.

Individual study data from [Davis 2011](#) show that 40 minutes of vigorous intensity physical activity on five days per week over a period of 13 weeks significantly improved mathematics achievement in overweight and obese children seven to 11 years of age ($N = 96$). The MD of mathematics scores was 3.00 points (95% CI 0.78 to 5.22; P value = 0.008) relative to the standardised test score, with a mean of 100 and an SD of 15. A statistically significant beneficial effect was also detected in the multicomponent lifestyle intervention of [Ahamed 2007](#). The MD of mathematics scores between the experimental groups of 73 overweight children nine to 11 years of age was 41 points (95% CI 6.5 to 75.50; P value = 0.02) relative to the standardised mean score of 500 (SD 70).

Pooled study data yielded an SMD in achievement scores of 17.94 units (95% CI -18.44 to 54.32; P value = 0.33; [Analysis 1.2](#)). Differences in lifestyle intervention design (single vs multicomponent) and dose (13 weeks vs one school year) are assumed to be the reasons for substantial heterogeneity between studies ($I^2 = 78\%$), which potentially resulted in the non-significant beneficial effects of lifestyle interventions on mathematics achievement.

2.2 Language achievement

Language achievement included both reading and writing skills of children and adolescents and was assessed by [Ahamed 2007](#). Results from this single study showed no significant effect of a

school-based, multicomponent lifestyle intervention, aiming to increase physical activity and fruit and vegetable intake, on language achievement in 73 overweight or obese children (nine to 11 years of age). The MD of language achievement scores between intervention and control groups was 27.97 points (95% CI -5.35 to 61.29; P value = 0.10; scale mean 500, SD 70) (Analysis 1.3).

2.3 Reading achievement

Similar to mathematics achievement, reading achievement was assessed by the two studies, which differed in types of interventions (after-school physical activity vs school-based physical activity and dietary changes) and intervention duration (13 weeks vs one school year), as well as in the tools used to assess reading achievement (Woodcock-Johnson Tests of Achievement III vs Canadian Achievement Test-3). Individual study data from both studies suggested no significant beneficial effect of the interventions on reading achievement (Ahamed 2007; Davis 2011). The MD was 0.00 (95% CI -2.22 to 2.22; P value = 1.00) relative to the standardised test score, with a mean of 100 and an SD of 15 in Davis 2011, and 12.76 units (95% CI -16.74 to 42.25; P value = 0.40; scale mean 500, SD 70) in Ahamed 2007. No statistical heterogeneity was detected after the two studies were combined (SMD 0.07 units, 95% CI -2.14 to 2.28; P value = 0.95; $I^2 = 0\%$) (Analysis 1.4).

2.4. Writing achievement

None of the included studies provided data on the effects of lifestyle interventions on writing achievement in overweight or obese children and adolescents.

2.5. Vocabulary achievement

Vocabulary achievement was assessed by one study (Winter 2011) using the Peabody Picture Vocabulary Test III. No evidence was found of an effect of lifestyle education combined with encouragement in increasing physical activity on vocabulary skills in overweight and obese preschool children (three to five years of age) regardless of whether missing data were imputed. The proportion of missing data that required imputation was 27.5% of the total sample. This proportion is considered to be high (Fewtrell 2008). Therefore, we reported the results for the study population with postintervention measures separately from the results after imputation of missing postintervention data. The MD for imputed data was 1.19 units (95% CI -4.04 to 6.42; P value = 0.69; N = 80); the MD for 66 participants without missing data was 2.60 units (95% CI -3.04 to 8.24; P value = 0.40) relative to the standardised test score, with a mean of 100 and an SD of 15 (Analysis 1.5).

3. Special education classes

No study provided data on the effects of lifestyle interventions on the need for special education classes or on reduction of time allocated for special education classes.

Secondary outcomes

1. Cognitive function

Data for evaluating the effects of lifestyle intervention on cognitive function were available from three studies (Davis 2011; Staiano 2012; Wirt 2013). As for the primary outcomes, findings for each study are described by types of outcome measures and, when suitable, results of meta-analyses, which also describe heterogeneity between studies, are presented. The low number of included studies prevented us from conducting meaningful subgroup analyses. All three studies delivered a physical activity intervention, and one of the three studies also included healthy lifestyle education (Wirt 2013). We corrected the number of participants for cluster randomisation for Wirt 2013 and calculated the effective sample size (see Unit of analysis issues).

1.1 Attention

Davis 2011 and Wirt 2013 assessed the effects of lifestyle interventions on attention abilities in overweight and obese children. No significant evidence showed a beneficial effect of 40 minutes of vigorous aerobic physical activity, on five days per week for a total of 13 weeks, on attention scores in 116 children seven to 11 years of age, as measured by the Das-Naglieri-Cognitive Assessment System. The MD was 0.00 units (95% CI -3.05 to 3.05; P value = 1.00) relative to the standardised test score, with a mean of 100 and an SD of 15 (Davis 2011). In contrast, an intervention combining lifestyle education and physical activity lessons in school over one school year indicated a significant beneficial effect of attention scores in the preschool-aged control group (N = 27) (Wirt 2013). The MD was -4.47 units (95% CI -8.55 to -0.39; P value = 0.03; standardised scale mean 50, SD 10). Wirt 2013 used the KiTAP tool to assess attention abilities.

Meta-analysis indicated moderate heterogeneity ($I^2 = 56\%$) between the combined studies; this is most likely explained by the different types of interventions. Combined results showed no statistically significant evidence of the effects of lifestyle interventions on attention ability in 143 overweight and obese children six to 11 years of age based on two studies (SMD -0.25 units, 95% CI -0.92 to 0.41; P value = 0.46) (Analysis 1.6).

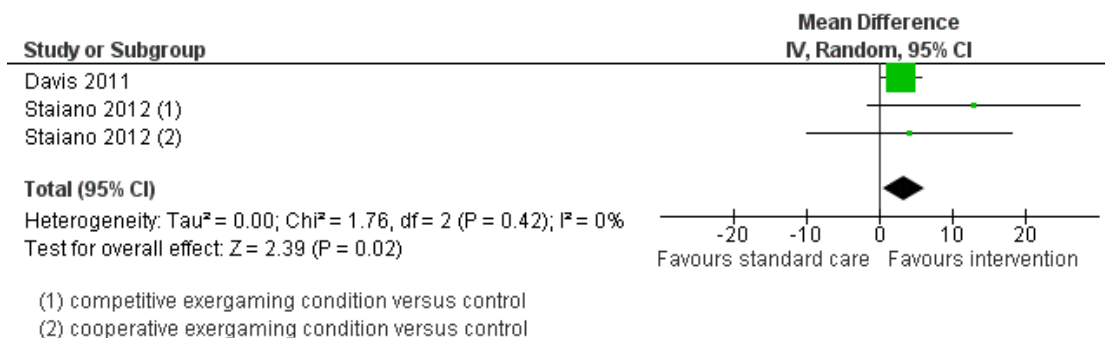
1.2 Executive function

Davis 2011 and Staiano 2012 reported findings on executive function in overweight and obese children and adolescents after participation in a physical activity intervention. Individual study data by Davis 2011 suggest that an after-school vigorous intensity physical activity intervention (40 minutes on five days per week over 13 weeks) improved executive function scores by three points (95%

CI 0.09 to 5.91; P value = 0.04; scale mean 100, SD 15; N = 116), as assessed by the planning scale of the Das-Naglieri-Cognitive Assessment System. On the contrary, a school-based exergaming intervention, with a competitive or cooperative condition that took place, on average, once a week for 30 to 60 minutes, was not beneficial in improving the executive function of 52 children 15 to 18 years of age compared with usual school routine (Staiano 2012). The MD for the cooperative exergaming condition was 4.18 (95% CI -9.90 to 18.26; P value = 0.56), and the MD for the competitive condition was 12.99 (95% CI -1.54 to 27.52; P value = 0.08). Executive function was assessed using the Design Fluency and Trail-Making subscales of the Delis-Kaplan Executive Function System (scale mean 10, SD 3).

Despite the difference in children's ages between studies, these studies are similar in methodology and outcome; hence, we performed a meta-analysis, which suggested that physical activity interventions can improve executive function in 170 overweight or obese children and adolescents seven to 18 years of age. The MD was 3.42 units (95% CI 0.62 to 6.22; P value = 0.02; I² = 0%) (Analysis 1.7; Figure 5). One study reported postintervention scores (Davis 2011), and the other study reported change scores (Staiano 2012). Therefore, we used the mean difference, rather than the standardised mean difference, to evaluate the effects of physical activity on executive function in overweight and obese children (Higgins 2011).

Figure 5. Forest plot of comparison: I Lifestyle interventions versus standard care, outcome: I.7 Executive function.



1.3 Inhibitory control

One study assessed the effects of school-based lifestyle education, including physical activity lessons for a period of one year, on inhibitory control in overweight or obese children (Wirt 2013). No significant evidence was found of an intervention effect on inhibitory control in 18 overweight or obese preschool children (six to eight years of age). The MD was 0.26 units (95% CI -1.27 to 1.79; P value = 0.74; standardised scale mean 50, SD 10) (Analysis 1.8).

1.4 Working memory

Working memory was assessed by the successive processing scale of the Das-Naglieri-Cognitive Assessment System. Results show that 40 minutes of vigorous intensity physical activity on five days per week, over a total of 13 weeks, significantly improved working memory in overweight and obese children (N = 116) seven to 11 years of age (Davis 2011). The MD of working memory scores between intervention and control groups was 3.00 units (95% CI 0.51 to 5.49; P value = 0.02) relative to the standardised test score,

with a mean of 100 and an SD of 15 (Analysis 1.9).

1.5 Simultaneous processing

The simultaneous processing scale of the Das-Naglieri-Cognitive Assessment System tests verbal and non-verbal spatial relations and memory. No significant evidence was found of an effect of the after-school physical activity intervention of Davis 2011 on simultaneous processing ability in 116 overweight or obese children seven to 11 years of age. The MD was 1.00 unit (95% CI -2.19 to 4.19; P value = 0.54) relative to the standardised test score, with a mean of 100 and an SD of 15 (Analysis 1.10).

2. Future success

No study provided data on the effects of lifestyle interventions on future success such as years of schooling, earning or college enrolment for overweight or obese children and adolescents.

3. Obesity indices

The effects of lifestyle interventions on body weight status were assessed only for included studies that indicated a significant effect (positive or negative) on at least one of the above outcome measures. Four of six included studies reported a significant change in measures of school achievement and/or cognitive function (Davis 2011; Johnston 2013; Staiano 2012; Wirt 2013). Staiano 2012, however, reported an intervention effect on body weight only, which is not considered a reliable tool for determining overweight and obesity. Therefore only the results of Davis 2011, Johnston 2013 and Wirt 2013 are presented.

3.1. Body mass index (BMI) z-score

Two studies provided data on the effects of a physical activity intervention (Davis 2011) and a multicomponent intervention (Johnston 2013) on BMI z-scores. Johnston 2013 provided change scores, and Davis 2011 reported postintervention BMI z-scores. Findings from Davis 2011 suggest a significant beneficial effect on the BMI z-scores of overweight and obese children in the control group. The MD was 0.12 BMI z-scores (95% CI 0.07 to 0.17; $P < 0.001$) (Davis 2011). Evidence from the multicomponent intervention (school-based lifestyle education and nutritional changes) shows a small but significant beneficial effect on changes in BMI z-scores in 321 overweight and obese children, with an MD of -0.06 BMI z-scores (95% CI -0.12 to 0.00; P value = 0.04). Meta-analysis including both studies showed substantial heterogeneity between studies ($I^2 = 96\%$), which can be explained by substantial methodological differences in the interventions (type, setting, duration) (Analysis 1.11).

3.2. Body mass index (BMI) standard deviation score (SDS)

A school-based lifestyle education intervention, including physically active lessons, had an effect on BMI SDS that was not statistically significant (Wirt 2013). The MD was 0.34 standard deviations (95% CI -0.01 to 0.69; P value = 0.06; $N = 30$) (Analysis 1.12).

3.3. Body mass index (BMI) centile

No significant effect of lifestyle interventions on BMI centiles was found in 30 overweight or obese children six to 11 years of age. The MD was 2.26 centiles (95% CI -0.86 to 5.38; P value = 0.16) (Wirt 2013; Analysis 1.13).

Sensitivity analysis

The low number of included studies limits the applicability of subgroup analysis and sensitivity analysis. Nevertheless, sensitivity analyses were performed to consider the impact of cluster-RCTs and/or 'high risk' attrition bias on the intervention effect. Sensitivity analyses show that results on reading achievement, executive function and attention and the overall conclusion were not affected by the inclusion of cluster-RCTs and studies with high attrition. However, results on the effects of lifestyle interventions on overall school achievement and on mathematics achievement became significantly statistically when the cluster-RCT, which was also at 'high risk' of attrition bias, was excluded. Sensitivity analyses suggested a beneficial effect of a school-based, healthy lifestyle education and nutrition intervention and an aerobic physical activity intervention on overall school achievement and on mathematics achievement in overweight and obese primary school children, respectively.

ADDITIONAL SUMMARY OF FINDINGS *[Explanation]*

Lifestyle interventions versus standard care for improving school achievement in overweight or obese children and adolescents						
Patient or population: patients with improving school achievement among overweight or obese children and adolescents						
Settings:						
Intervention: lifestyle interventions versus standard care						
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Lifestyle interventions versus standard care				
Overall school achievement Grade point average obtained from school records and Canadian Achievement Test (CAT-3) Follow-up: one to two years		Mean overall school achievement in the intervention groups was 0.19 standard deviations higher (0.36 lower to 0.75 higher)		385 (two studies)	⊕⊕○○ low ^{1,2,3}	
Mathematics achievement Woodcock-Johnson Tests of Achievement III and Canadian Achievement Test (CAT-3) Follow-up: three to 12 months		Mean mathematics achievement in the intervention groups was 17.94 standard deviations higher (18.44 to 54.32 higher)		151 (two studies)	⊕⊕⊕○ moderate ¹	

<p>Language achievement Canadian Achievement Test (CAT-3) Scale from zero to 1000 Follow-up: mean one year</p>	<p>Mean language achievement in the control groups was 583.67 points</p>	<p>Mean language achievement in the intervention groups was 27.97 higher (5.35 lower to 61.29 higher)</p>		<p>64 (one study)</p>	<p>⊕○○○ very low^{4,5,6}</p>
<p>Reading achievement Woodcock-Johnson Tests of Achievement III and Canadian Achievement Test (CAT-3) Follow-up: three to 12 months</p>		<p>Mean reading achievement in the intervention groups was 0.07 standard deviations higher (2.14 lower to 2.28 higher)</p>		<p>160 (two studies)</p>	<p>⊕⊕⊕○ moderate¹</p>
<p>Writing achievement</p>	<p>Study population</p> <p>See comment</p> <p>Moderate</p>	<p>Not estimable</p>	<p>zero (zero)</p>	<p>See comment</p>	<p>No evidence available</p>
<p>Vocabulary achievement Peabody Picture Vocabulary Test III Scale from zero to 200 Follow-up: mean 24 weeks</p>	<p>Mean vocabulary achievement in the control groups was 84.17 points</p>	<p>Mean vocabulary achievement in the intervention groups was 1.19 higher (4.62 lower to 7.00 higher)</p>		<p>80 (one study)</p>	<p>⊕⊕○○ low^{5,6}</p>
<p>Special education classes</p>	<p>Study population</p> <p>See comment</p> <p>Moderate</p>	<p>Not estimable</p>	<p>zero (zero)</p>	<p>See comment</p>	<p>No evidence available</p>

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio.

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

¹Inconsistency due to variation in intervention type and duration.

²Inconsistency of findings potentially due to different intervention duration (i.e. intervention dose).

³Interventions were aimed at the general population (i.e. normal weight and overweight/obese children).

⁴High risk of attrition bias.

⁵The study was aimed at the general population rather than overweight or obese children.

⁶The study included a small number of children, which resulted in a wide confidence interval.

DISCUSSION

Summary of main results

School achievement. Of the six included studies, four assessed the effects of lifestyle interventions on school achievement in overweight and obese children. Studies used different concepts of school achievement (i.e. overall school achievement or achievement in specific school subjects), which meant that only one or two studies could be included per outcome measure for analysis. No evidence was found of a beneficial effect of multicomponent lifestyle interventions on changes in overall school achievement in overweight and obese children seven to 11 years of age (Ahamed 2007; Johnston 2013). However, when both available studies were considered separately, the study with a lower risk of bias and a longer intervention duration suggested a small but significant benefit of a multicomponent intervention (MD 1.78 points, 95% CI 0.8 to 2.76; $P < 0.001$; scale range zero to 100; Johnston 2013). Similarly beneficial effects were detected for mathematics achievement. Combined results of available studies did not indicate improvement in mathematics achievement in the intervention group, most likely attributable to the large heterogeneity of the studies in terms of types and duration of interventions. However, after sensitivity analysis, individual study findings on the physical activity only intervention yielded an increase of three points in mathematics scores for overweight and obese children (95% CI 0.78 to 5.22; P value = 0.008; scale mean 100, SD 15) (Davis 2011). No statistically significant evidence was found for improvement in reading achievement, language achievement and vocabulary skills.

Cognitive function. Three studies investigated the effects of lifestyle interventions on five different specific cognitive abilities: executive function, inhibitory control, attention, working memory and simultaneous processing. Results showed significant improvement in executive function and working memory in overweight and obese children and adolescents (Davis 2011; Staiano 2012). The MD for executive function was 3.42 (95% CI 0.62 to 6.22; P value = 0.02) and for working memory 3.00 (95% CI 0.51 to 5.49; P value = 0.02). No significant evidence was found of a beneficial effect of lifestyle interventions on inhibition control (Wirt 2013), attention (Davis 2011; Wirt 2013) or simultaneous processing (Davis 2011) in overweight and obese children.

Future success. No data currently exist on whether lifestyle interventions for overweight or obese children and adolescents influence indices of future success once schooling has been completed.

Obesity indices. We analysed the effects of lifestyle interventions on obesity indices in studies that indicated a statistically significant effect of lifestyle interventions on school achievement or cognitive function. This enabled us to assess whether changes in outcome variables occurred independently of changes in obesity in three studies. One study suggested a small but significant beneficial effect on both average achievement and BMI z-scores (Johnston 2013); this was the largest and longest trial at low risk of bias. Another study reported a beneficial effect on BMI z-scores in the

control group (Davis 2011). No evidence was found of a statistically significant benefit of lifestyle interventions for BMI SDSs and BMI centiles (Wirt 2013).

Overall completeness and applicability of evidence

Very few studies have investigated the effects of lifestyle interventions on school achievement or cognition in overweight and obese children and adolescents, and reported studies have a range of methodological issues (see [Quality of the evidence](#)). During the literature review, we faced several challenges related to the nature of the intervention, the study population and outcomes. A lifestyle intervention is a broad and complex construct. We followed the definition used by clinical guidelines for the prevention and treatment of childhood obesity (see [Description of the intervention](#)) and developed the search strategy on this basis. We might have missed studies that applied childhood obesity-related lifestyle interventions that fall outside the definition used. Moreover, our literature search focused on lifestyle intervention studies that intended to prevent or reduce childhood obesity. Studies that employed a lifestyle intervention that is part of paediatric weight management but was not provided to prevent or reduce obesity were likely not to be included in this review. Our population group of interest-overweight and obese children and adolescents-is a very specific, yet substantial and increasing, subgroup of the general population. Many studies did not report results of the overweight or obese subgroup separately from those of normal weight children. For some studies, the data were not obtainable to date. Finally, lifestyle intervention studies in this population do not tend to assess and/or report school achievement, cognitive function or future success as primary or secondary outcomes.

All included studies were conducted in high-income countries. Although some studies targeted low-income children (Staiano 2012; Winter 2011), evidence might not be applicable to low- and middle-income countries. Available evidence for school achievement included children of primary school age (six to 11 years) only. Therefore the effects of lifestyle interventions on school achievement in preschool children and adolescents in secondary/high school need to be determined in future studies. In contrast, evidence for cognitive function included a broad age range-from primary school-aged children to high school students up to 18 years of age. No study reported the effects of lifestyle interventions on future success.

Most studies investigated the effects of multicomponent lifestyle interventions on school achievement and cognitive function comprising a nutrition component (e.g. modification of school meals towards nutrient-dense food), a physical activity component and a healthy lifestyle education component. Two studies delivered a single component physical activity intervention. Evidence is lacking on the effects of behaviour change interventions based on established behaviour change techniques for the treatment of childhood

obesity, such as stimulus control and self monitoring (NICE 2013; SIGN 2010). None of the included studies employed a single component intervention on healthy diet or reduced intake of sugar-sweetened beverages. Additionally, none of the included studies attempted to determine specifically the effects of reduced sedentary behaviour on school achievement and cognitive function. However, the healthy lifestyle education component by Wirt 2013 included lessons on reducing media screen time, and Ahamed 2007 and Johnston 2013 delivered physically active classroom lessons. Both lifestyle education on reducing media screen time and physically active lessons might be considered as interventions to decrease sedentary behaviour (time spent sitting). The body of available evidence does not allow us to explore whether a specific component of a lifestyle intervention is more effective than another, or whether the multicomponent intervention proves to be the better approach for improving school achievement and cognitive function in overweight and obese children and adolescents. Because all studies performed postintervention measures immediately after intervention with no further follow-up, no evidence on retention of the effect is available.

Overall, the total number of overweight and obese children included in this review is low (N = 674). This limits the generalisability of study results. Moreover, most included studies targeted the general population (normal weight and overweight or obese children), and this might influence the effects of interventions on school achievement and cognition in the overweight and obese paediatric population. Only two studies restricted participants to overweight or obese children and adolescents (Davis 2011; Staiano 2012). These two studies reported promising effects of physical activity interventions on school and cognitive outcomes, but methodological issues may limit applicability of findings for clinical and public health practice.

Only three studies allowed an exploration of whether changes in academic and cognitive abilities were connected to changes in indices of obesity. This connection is unclear because of conflicting findings and variations in study architecture.

Quality of the evidence

We used the GRADEpro software developed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group (GRADEpro 2008) to assess and grade the quality of evidence of primary outcomes. We performed a sensitivity analysis by generating two 'Summary of findings' tables; the first excluded studies with high risk of bias (Summary of findings for the main comparison), and the second included all studies (Summary of findings 2).

Limitations in study design and implementation were noted for language achievement, and a high risk of attrition bias was detected. We considered this limitation to lower confidence in the estimate of effect; therefore we downgraded the evidence by one level. Risk of attrition bias was not considered as a factor affecting

the quality of evidence for overall school achievement, mathematics achievement and reading achievement because studies of higher weight were of low risk for attrition bias. Studies aimed at the general population, not at overweight or obese children explicitly, suggested indirectness of outcomes. This occurred for all primary outcomes. However, we downgraded the quality of evidence by one level only for overall school achievement, language achievement and vocabulary achievement. Mathematics and reading achievements were not downgraded for indirectness because the study of higher weight was not affected by indirectness. Moreover, the small sample size of two included studies might suggest imprecision of evidence (wide confidence intervals) for language and vocabulary achievement. Thus, we downgraded the quality for language and vocabulary achievement by one level. We downgraded the quality of evidence for overall school achievement, mathematics achievement and reading achievement by one level as the result of inconsistency of findings most likely caused by differences between studies in intervention type and duration. Given the low number of included studies (fewer than 10 per meta-analysis), we did not assess publication bias using the funnel plot. Risk of bias assessment indicated a low risk of selective reporting for all studies/outcomes, which we regarded as unlikely to negatively affect the quality of evidence. In summary, the quality of evidence for overall school achievement was low, for mathematics and reading achievement moderate, for vocabulary achievement low and for language achievement very low.

Throughout the review, we have prioritised reporting of sensitivity analyses when risk of bias and differences in intervention type and duration were suspected to have substantially influenced the findings. After sensitivity analyses were conducted, the quality of evidence improved for the outcomes of overall achievement, mathematics achievement and reading achievement (Summary of findings for the main comparison). The quality of evidence for overall school achievement was assessed to be moderate; evidence for indirectness was downgraded because the intervention was aimed at the general population. We did not downgrade the quality of evidence for both mathematics and reading achievement; thus the quality was high.

Potential biases in the review process

We intended to review evidence on the effects of an intervention, which is difficult to define in a specific subgroup of the general population; therefore the following limitations should be considered.

First, although we believe that we identified all relevant studies on the reviewed topic, the high number of additional records not identified through our predefined literature search may indicate limitations of our search strategy. However, most of the additionally screened records (identified from reference lists of systematic reviews) described non-randomised lifestyle interventions and/or interventions without specific focus on overweight or obese chil-

dren. Hence, those records were not intended to be identified by our search strategy, because the studies deviated from the study design and population criteria. On the other hand, because of this, we might have missed relevant studies that included the general population, and separate outcomes for overweight or obese children and adolescents might be obtainable. Of the 62 additional records, only one met the inclusion criteria. Additionally, we might have missed relevant outcomes of at least one study (dissertation) because we could not find contact details of the study author.

Second, given that only a very small number of studies per outcome (one or two studies) with mainly low sample sizes were available, the strength of evidence on the effects of lifestyle interventions for improving school achievement and/or cognitive function in overweight and obese children and youth is limited. Information on whether the studies were adequately powered was insufficient. This was due in part to the fact that data on the overweight and obese subpopulation were provided, and studies were potentially powered for the total study sample. Therefore, both significantly beneficial effects of lifestyle interventions and evidence of no effect need to be considered cautiously.

Third, the absence of an effect might also be attributable to poor adherence to the experimental condition, particularly when the intervention was applied in participants' homes (e.g. physical activity homework tasks). Assessment of participants' compliance with the lifestyle intervention was often poorly reported. We observed a similar bias for assessment of adherence to the control condition. Most studies did not attempt to evaluate and/or report whether the control group maintained its standard care during the trial period. For example, changes in school policy concerning healthy lifestyle factors such as improved school meals or physical activity opportunities during recess could potentially bias the intervention effects of experimental trials. The same may account for engagement in lifestyle changes at the family or child level.

Fourth, most studies linking lifestyle interventions to school achievement and cognitive function in overweight and obese children and youth did not address co-morbidities when selecting the study population. Several co-morbidities are associated with childhood obesity and/or school and cognitive outcomes, including asthma, hypertension, type 2 diabetes and attention-deficit hyperactivity disorder (ADHD). For example, lifestyle interventions for prevention and treatment of obesity (i.e. nutrition, physical education, and health education) also had a significantly beneficial effect on school achievement in children with asthma (Murray 2007). The actual treatment effect of lifestyle interventions in overweight children with co-morbidities may be underestimated or overestimated. On the other hand, Davis 2011 stated that inclusion of overweight children with ADHD did not change the findings on treatment effects.

Fifth, studies used a wide range of school achievement and cognitive function test tools. Although there tend to be correlations between cognitive function tests in particular (because of the general cognitive factor g), different cognitive tests vary in their speci-

ficity for different cognitive domains. Moreover, successive testing before and after the intervention is likely to improve participant scores through repeated measures and regression to the mean. Thus, an improvement may not be due to the intervention, although the use of a control group allows some control for this. On the other hand, small participant numbers limit the ability to minimise bias.

Agreements and disagreements with other studies or reviews

To our knowledge, no studies have been conducted other than those reviewed and no other (systematic) literature reviews have been performed on this specific topic. However, systematic reviews are available on the effects of physical activity, diet and general school health interventions on school and cognitive achievements in the general population. Although these systematic reviews may include some overweight and obese children, they lack a separately analysed overweight and obese paediatric subgroup; thus they are difficult to compare with this systematic review.

Findings from meta-analyses on physical activity interventions for school achievement and/or cognitive function in the general child and youth population are in agreement with the results of this systematic review, which focused on effects on overweight or obese children only—that is, that physical activity interventions improved school and cognitive outcomes. Sibley 2003 stated that the overall estimated effect size from 16 true experimental studies was 0.24 units (SD 0.24; $P < 0.05$). A meta-analysis of 39 experimental and quasi-experimental studies by Fedewa 2011 revealed an overall effect size of 0.35 units (standard error (SE) 0.04, 95% CI 0.27 to 0.43; random-effects model). The systematic review on the effects of breakfast consumption and healthy diets on educational achievement by Ells 2008 confirmed the findings of this review in the sense that review authors reported lack of high-quality studies and lack of convincing evidence. Similar results were obtained by Murray 2007, who systematically reviewed the literature on effects of co-ordinated school health programmes, which included, for example, nutrition service, physical education and health education, on school achievement.

Besides the focus on the general child and youth population, these systematic reviews differ from this review in their methodological quality. A thorough assessment of the quality and risk of bias of included RCTs was missing in most of the above studies, and a less rigorous literature search was performed in some of the systematic reviews (e.g. search of selected electronic databases only).

AUTHORS' CONCLUSIONS

Implications for practice

Currently, too few data are available to influence practice. However, evidence on the effects of lifestyle interventions does indicate a significant, albeit small, improvement in overall school achievement, mathematics achievement, executive function and working memory in overweight or obese children living in high-income countries. The magnitude of improvement could have practical significance given, for example, that a mean difference of three points represents one third of the change in score required to change from 'low average' to 'average' on a zero to 200 scale of mathematics achievement on the Woodcock-Johnson Tests of Achievement III. An overweight or obese child in the upper range of 'low-average' achievement might benefit from a lifestyle intervention moving into the 'average' achievement category. Therefore, and in addition to previous studies, which have shown beneficial effects for children in general, lifestyle interventions implemented in the school setting, or as after-school programmes, may have the potential to benefit school achievement and associated specific cognitive abilities in overweight and obese children and adolescents. Although these benefits are small, the high prevalence of obesity among children means that the gains could have an impact.

Most included studies took place as part of the curriculum or were implemented in a comprehensive whole-school approach, indicating that similar interventions are feasible to introduce into school practice. Health policy makers may wish to consider these potential additional benefits when promoting physical activity and healthy eating (i.e. body weight-related behaviours) in schools.

Evidence on the effects of lifestyle interventions on school achievement and cognitive function in overweight and obese children conducted in clinical and community settings is missing, and so no implications for clinical practice and community interventions can be drawn.

Implications for research

Overall, additional well-designed randomised controlled lifestyle intervention trials in overweight and obese children three to 18 years of age are needed to assess school achievement and/or cognitive function, particularly in low- and middle-income coun-

tries, where the prevalence of childhood obesity is rising (WHO 2012). Future childhood obesity treatment trials in both clinical and school settings could consider including school achievement and cognitive outcomes. Studies conducted in the general paediatric population could report school achievement-related outcomes separately for the overweight subgroup. Evidence on the effects of dietary interventions, behaviour change techniques and reduced sedentary behaviour is needed. Low cognitive abilities may be associated with behaviours that cause obesity (reverse causation); therefore identifying which components of lifestyle interventions benefit specific cognitive domains could optimise the physical and cognitive outcomes of obesity treatment programmes. Longer-term follow-up trials are needed to determine whether improvements in school achievement and cognitive function are sustainable over time and thus affect future success. Given that engagement in lifestyle interventions and school achievement and cognitive function vary between gender and ethnicity (Demack 2000), it is important that future trials consider these factors. High rates of loss to follow-up assessment are a common problem in lifestyle interventions, particularly those involving overweight and obese children and adolescents. To reduce the risk of attrition bias, researchers might wish to consider methods to impute missing outcome data in their analysis and to report characteristics of and reasons for missing data. In addition, availability of larger studies might permit investigations of whether a dose-response relationship exists between lifestyle interventions and improvement in school achievement and cognitive function in overweight children and adolescents.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Ahamed 2007

Methods	<p>Study design: cluster-randomised controlled trial</p> <p>Randomisation: Schools were stratified by size and geographical location. Randomisation of schools into three groups (two intervention groups and one control group)</p> <p>Sequence generation: not reported</p> <p>Allocation concealment: not reported</p> <p>N schools = 10 (seven intervention schools, three control schools)</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinding to true purpose of the study not reported 2. Providers: blinding to true purpose of the study not reported 3. Outcome assessor: blinding not reported <p>Duration of intervention: one school year</p> <p>Follow-up: immediately postintervention</p> <p>Unit of analysis: child</p> <p>Exclusion criteria: "school already undertaking a school-based physical activity program"</p> <p>Attrition (children): 29.1%</p> <p>Analysis: Authors provided raw data. Review authors analysed the data using the independent <i>t</i>-test and adjusting for the design effect. No adjustments for confounders were performed</p>
Participants	<p>N (randomly assigned): 103 (78 intervention, 25 control)</p> <p>N (analysed): 73 (52 intervention, 21 control)</p> <p>Reasons for attrition: Children moved schools or were absent on the day of testing (five times higher in intervention than control school), school chose not to send participants' test results to the CAT-3 test centre for scoring (control school), school administered the wrong test at follow-up (intervention school)</p> <p>Age range: nine to 11 years (fourth and fifth grades), mean age: 10.1 ± 0.6 years</p> <p>Sex: 29% female; intervention group 48% female, control group 19% female</p> <p>Ethnicity: 43% Asian, 21% Caucasian, 9% other</p> <p>Geographical region: British Columbia, Canada</p>
Interventions	<p>Comparison: Action Schools! BC versus standard care</p> <p>Intervention: Action Schools! BC is a comprehensive, multicomponent intervention providing tools for schools and teachers to use in promoting physical activity and healthy eating in different settings. These include the school environment (healthy eating posters), scheduled PE, classroom action, family and community (e.g. walking school bus), extracurricular activities (e.g. dance club) and school spirit (e.g. Hike across Canada challenge). Extracurricular and school spirit activities were provided by only a small number of intervention schools</p> <ol style="list-style-type: none"> 1. Physical activity: Classroom- and/or school environment-based physical activity for 15 minutes per day on five days/wk delivered by trained classroom teachers. Activities included hip hop dancing, skipping, jumping, chair aerobics, yoga and strength work. This activity was provided in addition to 40 minutes of physical education twice per week to engage children in 150 minutes of physical activity/wk. Compliance with intervention was assessed by the classroom teacher through daily

	<p>physical activity logs reporting type, duration and frequency</p> <p>2. Nutrition: Across the different settings, a fruit and vegetable (F&V) intervention was employed that focused on increasing intake of F&V; improving knowledge, attitudes and perceptions regarding F&V; and strengthening willingness to try new F&V</p> <p>Standard care: usual school practice</p>
Outcomes	<p>Outcome 1: School achievement: Total and subject-specific scores for mathematics, reading and language assessed using the Canadian Achievement Test (CAT-3). The test was administered by classroom teachers and was scored for most but not one school at the CAT-3 test centre. One school scored the test locally</p> <p>Outcome 2: Obesity indices: Weight and height were measured and BMI calculated. Overweight and obesity were defined on the basis of IOTF cutoffs and CDC BMI-for-age growth tables (overweight = BMI > 85th percentile)</p>
Notes	<ol style="list-style-type: none"> 1. Authors kindly provided raw data for overweight/obese children 2. Sample size calculation was performed for total sample (normal weight and overweight/obese children) 3. Funding sources: 2010 Legacies Now and the BC Provincial Health Service Authority in collaboration with the BC Ministry for Health Research Scholar

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote (from report): "Schools were then remotely randomized..." Quote (from email correspondence): "randomisation was done by random number draw by a third party"
Allocation concealment (selection bias)	Low risk	Quote (from email correspondence): "Yes, the 10 schools were randomized at once"
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: Authors provided raw data from complete baseline and follow-up data sets only. Therefore, incomplete follow-up data were not imputed and included in the analysis. Characteristics of missing data were not provided
Selective reporting (reporting bias)	Low risk	Comment: All prespecified achievement outcomes were reported
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Quote (from email correspondence): "The primary purpose of Action Schools! BC was not to improve academic performance" Comment: Blinding of children and personnel regarding the experimental condi-

Ahamed 2007 (Continued)

		tion is not possible in a lifestyle intervention. Email correspondence with authors confirmed that participants and personnel were blinded to the true purpose of the study
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote (from report): "CAT-3 tests were administered by classroom teachers to [...] students in INT [intervention] and UP [usual practice] schools"
Comparability of baseline groups	Unclear risk	Quote (from report): "Schools were stratified by size and geographic location. [...] to accommodate different organisational structure of large versus small schools and different ethnic demographics between regions" Baseline characteristics between experimental groups were not significant besides school achievement scores, which were higher in the control school than in the intervention school
Other bias	Low risk	Comment: none detected

Davis 2011

Methods	<p>Study design: randomised controlled trial</p> <p>Sequence generation: random allocation by statistician, stratified by ethnicity and gender</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinded to true purpose of the study 2. Providers: blinding not possible in physical activity intervention 3. Outcome assessor: yes <p>Duration of intervention: 13 weeks</p> <p>Follow-up: immediately after intervention</p> <p>Unit of allocation: child</p> <p>Unit of analysis: child</p> <p>Attrition: 5.2% (six/116)</p> <p>Analysis: intention-to-treat analysis performed by last observation carried forward (LOCF) for all outcomes. Group differences calculated by analysis of covariance. Adjustment of outcomes for the confounders of gender, parental education, baseline scores and ethnicity</p>
Participants	<p>N (randomly assigned) = 116 (56 intervention, 60 control)</p> <p>N (completed) = 110 (54 intervention, 56 control)</p> <p>N (analysed) = 116 (110 + six LOCF)</p> <p>Reason for attrition: refused post-test (N = two intervention, N = three control), excluded because of psychiatric illness (n = one control)</p> <p>Age range: seven to 11 years, intervention group: mean (SD) = 9.3 (1.1); control group:</p>

	<p>mean (SD) = 9.4 (1.1) years Sex: intervention group 54% female; control group 62% female Ethnicity: intervention group: 64% black, 36% white; control group: 58% black, 42% white Inclusion criteria: children aged > 11 or < seven years, BMI ≥ 85th percentile relative to CDC 2000 US growth charts, taking medication for attention-deficit disorder when diagnosed Exclusion criteria: regular physical activity > one hour/wk, medical condition that affects outcome or limits intervention participation, participation in another study, on medication other than for attention-deficit disorder Mean weight status at entry: intervention group BMI z-score = 2.0 (0.43); control group BMI z-score = 2.1 (0.45) Geographical region: Georgia, USA</p>
Interventions	<p>Comparison: aerobic exercise group versus standard care Intervention: aerobic exercise group for 40 minutes per day, five times per week, over a mean total of 13 weeks. Five-minute warm-up phase consisting of brisk walking and static and dynamic stretching. Activities were selected on the basis of ease of comprehension, fun and eliciting intermittent vigorous movements. Children were encouraged to maintain a heart rate > 150 beats/min during running games, tag games, jump rope, modified basketball and football. No competition or skill enhancement. Intervention session ended with a cool-down including such activities as water break, slow walking and static stretching The intervention was delivered by qualified and trained research staff in an after-school programme at the gymnasium of the Georgia Prevention Institute. Compliance was assessed by observing and recording attendance and average heart rate daily for each child This study included a second intervention group, which was not included in this review (see notes) Standard care: continuation of usual activities All participating families were offered a monthly lifestyle education class covering the topics of healthy diet, physical activity and stress management</p>
Outcomes	<p>Outcome 1: School achievement: broad mathematics and reading skills on the Woodcock-Johnson Tests of Achievement III Outcome 2: Cognitive function: subscales for planning, attention, simultaneous successive use of the Das-Naglieri-Cognitive Assessment System. Both tests were administered by a qualified psychologist and personnel with graduate training in psychological assessment Outcome 3: Obesity indices: Quote “Body weight (in shorts and t-shirt) and height (without shoes) were measured with an electronic scale (Detecto, Web City, MO) and stadiometer (Tanita, Arlington Heights, IL) and converted to BMI and a BMI z-score (Epi Info, Centers for Disease Control and Prevention, Atlanta, 2003)”</p>
Notes	<ol style="list-style-type: none"> 1. Sample size calculation performed. 62 participants per group were estimated to provide 80% power to detect a difference between groups of 6.6 units 2. The second intervention arm included a 20-minute physical activity intervention followed by 20 minutes of sedentary activities such as board games, card games and drawing (low-dose intervention arm). This intervention group was excluded because the sedentary activities might have affected cognitive function without being defined as

	lifestyle interventions 3. Funding sources: National Institutes of Health, State of Georgia Biomedical Initiative grant to the Georgia Center for Prevention of Obesity and Related Disorders, Medical College of Georgia and University of Georgia	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote (from report): "... children were assigned randomly by a statistician..." Quote (from the report Davis 2012): "... each participant was assigned a uniform (0, 1) random number [...] within their respective ethnicity and sex group. If the number was between 0 and 0.33 the child was randomised to the low-dose group; between 0.34-0.67, to the high-dose group; and above 0.67, to the control group"
Allocation concealment (selection bias)	Low risk	Quote (from email correspondence): "I ensured allocation concealment by not permitting randomization by the statistician until baseline testing was completed. Only then were they randomized and their assignments communicated to the study coordinator, who informed the families"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: Provided participant flow chart indicated similar missing data in intervention and control groups Quote (from report): "Analyses were conducted using the last observation carried forward imputation for the [...] children who did not provide posttest data"
Selective reporting (reporting bias)	Low risk	Comment: All previously reported outcomes were reported
Blinding of participants and personnel (performance bias) All outcomes	Low risk	True purpose of the study was blinded by advertising it as "trial of aerobic exercise on child's health" (quote from report) Comment: Blinding of children and personnel regarding experimental condition is not possible in a physical activity intervention

Davis 2011 (Continued)

Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote (from report): "...Outcome assessors were unaware of child's experimental condition..."
Comparability of baseline groups	Low risk	Comment: comparable baseline groups present because of random allocation of participants into intervention and control groups
Other bias	Low risk	Comment: none detected

Johnston 2013

Methods	<p>Study design: cluster-randomised controlled trial</p> <p>Sequence generation: using a random sequence generator</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: not possible in lifestyle intervention, unclear whether blinded to true purpose of the study 2. Providers: not possible in lifestyle intervention, unclear whether blinded to true purpose of the study 3. Outcome assessor: no <p>Duration of intervention: two years</p> <p>Follow-up: immediately after intervention</p> <p>Unit of allocation: schools</p> <p>Unit of analysis: child</p> <p>N schools = seven (four intervention schools, three control schools)</p> <p>Attrition: 21% (68/321)</p> <p>Analysis: Intention-to-treat analysis was performed by last observation carried forward (LOCF) for all outcomes. Results were generated using generalised linear models, which accounted for the cluster effect</p>
Participants	<p>N (randomly assigned) = 321 (N intervention = 186, N control = 135)</p> <p>N (followed) = 253 (N intervention = 153, N control = 100)</p> <p>Reasons for attrition: absent at follow-up (N intervention = 14, N control = 11), no longer at school (N intervention = 19, N control = 24)</p> <p>Age: seven to nine years, mean age: 7.8 ± 0.4 (intervention group), 7.7 ± 0.4 (control group)</p> <p>Sex: intervention group 38.2% female, control group 45.9% female</p> <p>Ethnicity: intervention group-Hispanic 27.4%, black 26.9%, Asian 24.3%, white 21.5%; control group-Hispanic 29.6%, white 27.4%, black 26.7%, Asian 16.3%</p> <p>Inclusion/exclusion criteria: not reported</p> <p>Geographical region: Texas, USA</p>
Interventions	<p>Comparison: lifestyle education versus standard care</p> <p>Intervention: whole-school lifestyle education programme facilitated by a health professional involving curriculum material taught by trained teachers, school meal modification and nutrition counselling. Compliance with the intervention was assessed through direct weekly observation of teachers by the health professional and verbal self report</p>

	<p>from teachers</p> <p>1. Lifestyle education/behaviour change: Teachers were provided with 50 integrated lessons worth of curriculum material aiming to improve healthy diet (increased fruit and vegetable, breakfast, healthy snack, water consumption) and increase physical activity. Teachers were encouraged to teach lifestyle integrated lessons once a week, to conduct health-related activities every two weeks and to hold a school-wide health event once per semester. The intervention component included provision of additional health information at school functions by health professionals and involvement of school libraries, computers, art, music and physical education in delivery/complementation of lifestyle education</p> <p>2. Nutrition/Diet: Modification of school meals towards nutrient-dense food. Nutrition counselling was provided on an informal basis by a school nurse</p> <p>Standard care: Even though intervention material was provided to control schools, teachers reported using the material once a month or less often</p>	
Outcomes	<p>Outcome 1: School achievement: End of year final grades for reading, mathematics and science summarised as the GPA obtained from school records. The grade scale comprises scores between 0 and 100 points for each participant</p> <p>Outcome 2: Obesity indices: Age- and gender-specific BMI percentiles and BMI z-scores obtained from measured weight and height and by using formulas and data tables provided by the Centers for Disease Control and Prevention (CDC). Overweight was defined as a BMI \geq 85th percentile</p>	
Notes	<ol style="list-style-type: none"> 1. Authors were contacted 2. No sample size calculation was reported. Thus, this study might be at risk for a type two error 3. Funding source: not disclosed 	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote (from report): "7 schools were randomized using a random number generator"
Allocation concealment (selection bias)	Unclear risk	Comment: no information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote (from report): "Models were developed for both completers and intention-to-treat using the last observation carried forward (LOCF) method"
Selective reporting (reporting bias)	Unclear risk	Comment: no information provided
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: Blinding is not possible in lifestyle interventions. Unclear whether participants and personnel were blinded to the purpose of the study (in relation to the

Johnston 2013 (Continued)

		outcome of school achievement)
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Comment: no information provided
Comparability of baseline groups	Low risk	Quote (from report): “No differences were found between conditions with respect to baseline demographic or anthropometric variables” Comment: Baseline GPA of intervention and control groups indicated no statistically significant differences between experimental groups
Other bias	Low risk	Comment: No further bias was detected

Staiano 2012

Methods	<p>Study design: randomised controlled trial Randomisation: allocation stratified by gender Sequence generation: could not be obtained Blinding: 1. Children: blinded to true purpose of the study 2. Providers: blinded to true purpose of the study 3. Outcome assessor: yes Duration of intervention and follow up: 10 weeks of intervention Follow-up: immediately postintervention Unit of allocation: child Unit of analysis: child Inclusion/exclusion criteria: BMI > 75th percentile relative to CDC 2000 US reference growth charts Attrition: 27.0% (20/74) Analysis: three (conditions) × two (gender) analysis of variance, no adjustment for confounders reported</p>
Participants	<p>N (randomly assigned) = 74 (28 in competitive group one, 27 in cooperative group, 19 in control group) N (completed) = 54 (19 per intervention group, 16 in control group) Reason for attrition: self consciousness due to obesity, school truancy or dropout; school transfer; lack of interest; pregnancy; safety concerns about walking home in the dark; sports practice time conflicts; academic tutoring time conflicts, frequent headaches and an injury outside of the programme that required crutches. School administrators removed three students from the programme because of behavioural infractions external to the exergame intervention Age range: 15 to 19 years, mean = 16.5 years Sex: 57% female Ethnicity: all black Weight criterion: overweight = BMI ≥ 85th percentile, obese = BMI > 95th percentile</p>

	<p>relative to CDC 2000 US reference growth charts Weight status at entry: mean BMI = 93.9th percentile; overweight N = 12, obese N = 37 Setting: school Geographical region: Washington DC, USA</p>	
Interventions	<p>Comparison: competitive physical activity versus standard care, co-operative physical activity versus standard care Interventions: Nintendo Wii EA Sports Active exergame played in competitive condition individually or in co-operative condition in pairs for 30 to 60 minutes, five days per week, over a period of 10 weeks in total. Fitness video game included cardio activities (e.g. inline skating), sports games (basketball, volleyball, tennis, baseball) and strength training. Exergame routine was the same for both intervention groups. Routines varied on daily basis and gradually increased in difficulty throughout the study. Children in the competitive group were encouraged to win by earning top scores and expending most calories each time they played. Children in the co-operative group were encouraged to earn the highest possible score and to expend the most calories as a pair. Children were supervised during the exergame sessions. Compliance was assessed through attendance Standard care: continuation of usual school lunch and/or after-school activities (Quote: “Control participants continued usual daily activities, such as socializing with friends, tutoring, and sports team practice”)</p>	
Outcomes	<p>Outcome 1: Cognitive function: executive function (visual-spatial skills, response inhibition, motor planning, visual scanning, speed, cognitive flexibility) measured using the subscales Design Fluency and Trail-Making of the Delis-Kaplan Executive Function System. Tests were administered by a trained researcher and were coded by two research assistants; a third research assistant double-coded all tests Outcome 2: Obesity indices: body weight change: Body weight measured clothed without shoes by paediatricians and nurse practitioners at the school-based wellness clinic. Body weight remained unadjusted for height</p>	
Notes	<ol style="list-style-type: none"> 1. No sample size calculation was performed. Thus, this study might be at risk for a type two error 2. Five of the study participants (two boys, three girls) were not overweight or obese. However, this study was done with the intention for weight management, and the number of normal weight children is small when allocated into a control group and the two intervention groups 3. Participants attended on average one exergame session/wk 4. Time point of measurement of cognitive function potentially introduced a confounding effect of acute exercise on cognitive function 5. Funding sources: Robert Wood Johnson Foundation, Georgetown University 	
Risk of bias		
Bias	Authors’ judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote (from email correspondence): “An adult research coordinator drew a number to randomly assign condition. When conditions

		became imbalanced due to attrition, new participants were assigned consecutively to the next available condition to maintain sample size balance”
Allocation concealment (selection bias)	Unclear risk	Quote (from email correspondence): “Participants knew that they were assigned to 1 of 2 classrooms or else to the control group, but they did not know the research aim until the disclosure period at the end of the study”
Incomplete outcome data (attrition bias) All outcomes	High risk	Comment: Analysis was performed with data when both baseline and postintervention data were available. Therefore, study did not account for incomplete outcome data. No information available on characteristics of missing data
Selective reporting (reporting bias)	Low risk	Comment: Dissertation was assessed and all previously stated outcomes were reported in the article
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Comment: blinding not possible in exercise intervention Quote (from email correspondence): Children “did not know the research aim until the disclosure period at the end of the study” Comment: Personnel were also blinded to true purpose of the study (information obtained from email correspondence)
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote (from email correspondence): “The coders and data enterers were blinded to the participant’s condition”
Comparability of baseline groups	Low risk	Comment: comparable baseline groups present because of random allocation of participants to intervention and control groups
Other bias	High risk	Comment: Body weight change is an unreliable measure of adiposity, as it does not account for age- and gender-specific developmental variation

Methods	<p>Study design: cluster-randomised controlled trial</p> <p>Allocation: units of allocation were schools; allocation procedure to intervention and control groups not reported</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinding to true purpose of the study not reported 2. Providers: blinding to true purpose of the study not reported 3. Outcome assessor: blinding not reported <p>Duration of intervention: 24 weeks</p> <p>Follow-up: immediately postintervention</p> <p>N schools = four</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: not reported</p> <p>Attrition (children): 27.5%</p> <p>Analysis: Raw data were provided to review authors. Missing data were imputed using the last observation carried forward (LOCF) method. Summary statistics were calculated. Sample size was adjusted for cluster effect</p>
Participants	<p>N (recruited): 141 (70 in intervention group, 71 in control group)</p> <p>N (analysed): 125 (61 in intervention group, 64 in control group)</p> <p>Reasons for attrition: none reported</p> <p>Age: three to five years, mean age: 4.3 ± 0.54 years</p> <p>Sex: 50% female</p> <p>Ethnicity: “predominantly Latino of Mexican American origin”</p> <p>Geographical region: Texas, USA</p>
Interventions	<p>Comparison: Healthy & Ready to Learn intervention versus standard care</p> <p>Intervention: implemented at home and in school by trained parents and teachers. Compliance with the intervention assessed during weekly evaluations at teacher level. Parents interviewed monthly</p> <ol style="list-style-type: none"> 1. Lifestyle education: Parents and teachers read children’s books on health-related themes including nutrition and obesity prevention 2. Physical activity: Teachers and parents were trained to increase children’s time spent physically active in moderate to vigorous activity for 60 minutes/d. Activities were play-based and targeted specific gross motor skills. Physical activity equipment was provided <p>Standard care: Usual school curriculum and programmes different from the intervention</p>
Outcomes	<p>Outcome 1: School achievement: Receptive vocabulary skills were assessed with the Peabody Picture Vocabulary Test III, administered by trained researchers</p> <p>Outcome 2 Obesity indices: Weight and height were measured and BMI calculated. Overweight was defined as BMI 85th to 94th percentile; obesity was defined as BMI > 95th percentile based on gender-specific CDC BMI-for-age growth tables</p>
Notes	<ol style="list-style-type: none"> 1. Authors provided raw data for characteristic and outcome data for overweight or obese children 2. Funding sources: Baptist Health Foundation of San Antonio and The Max and Minnie Tomerlin Voelcker Fund
<i>Risk of bias</i>	

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Comment: no information provided. Unclear how random sequence was generated
Allocation concealment (selection bias)	Unclear risk	Comment: no information provided
Incomplete outcome data (attrition bias) All outcomes	Low risk	Comment: Study authors provided raw data on the overweight/obese subgroup. For 31 participants, no follow-up outcome data were available. Review authors imputed missing outcome data using the last observation carried forward method
Selective reporting (reporting bias)	Low risk	Comment: Outcome reported was predefined
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Comment: Blinding to lifestyle education and physical activity intervention was not possible. Information whether participants and personnel (teacher and parents) were blinded to the true purpose could not be obtained
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Comment: Information could not be obtained from study authors
Comparability of baseline groups	Low risk	Quote 1 (from report): "Data [...] were matched on the basis of geographical location, size of centre, and demographic characteristics" Quote 2 (from report): "The centre chosen served families that were similar in ethnicity, income and level of parental education" Quote 3 (from report): "Each centre [...] used a common curriculum, teacher professional development, and parent training program"
Other bias	Low risk	Comment: none detected

Methods	<p>Study design: cluster-randomised controlled trial</p> <p>Randomisation: Schools were the unit of allocation. Stratified randomisation was based on number of classes in grade one and/or grade two</p> <p>N randomly assigned = 91 schools (45 intervention, 46 control)</p> <p>N included = 86 schools (44 intervention, 42 control)</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinded to true purpose 2. Providers: blinded to true purpose 3. Outcome assessor: yes <p>Duration of intervention: one year</p> <p>Follow-up: immediately postintervention</p> <p>Inclusion criteria: teacher participation in the programme in the school year 2010-2011, informed consent of school heads, teachers and parents</p> <p>Exclusion criteria: no possibility to collect necessary data at the school, insufficient number of parental consents to collect child's data</p> <p>Unit of analysis: child</p> <p>Attrition (children): 24.3%</p> <p>Analysis: Authors provided means and standard deviation of raw data. Sample size was adjusted for cluster effect</p>
Participants	<p>N (included): 37 (23 overweight, 14 obese)</p> <p>N (completed): 30 (20 intervention group, 10 control group)</p> <p>N (analysed): 28 (inhibition control), 27 (attention)</p> <p>Reasons for attrition (for normal weight and overweight study population): parental withdrawal from study, change of school, dropout of class from study</p> <p>Age range: six to eight years, mean age: 7.4 ± 0.6 years</p> <p>Sex: 53% female</p> <p>Ethnicity: 52% with migration background</p> <p>Geographical region: Germany</p>
Interventions	<p>Comparison: lifestyle education and physical activity versus no treatment (waiting list)</p> <p>Intervention: delivered in the primary school setting (class and recess) by specifically trained usual primary school teachers and at home with parent involvement. Compliance with experimental conditions assessed through evaluation of other health promotion programmes and modifications in school and teaching environment</p> <ol style="list-style-type: none"> 1. Lifestyle education: healthy lifestyle education of 20 teaching sessions per year focusing on increased physical activity, reduced consumption of sugar-sweetened beverages and reduced screen time 2. Physical activity: two physically active breaks per school day of five to seven minutes and physical activity task to be performed at home involving parents
Outcomes	<p>Outcome 1: Cognitive function: assessment of attention, mental flexibility and inhibition control using the computer-based test battery of attention for children KiTAP (Kinderversion der Testbatterie zur Aufmerksamkeitsprüfung), administered by trained assessors</p> <p>Outcome 2: Obesity indices: (1) BMI percentiles and standard deviation scores calculated on the basis of measured body weight and height. Overweight = BMI > 90th percentile and obesity = BMI > 97th percentile relative to the German reference population from 1985 to 1999. (2) Waist circumference was measured "halfway between the lower</p>

	costal border and the iliac crest using a metal tape measure”	
Notes	<ol style="list-style-type: none"> 1. Researchers kindly provided unpublished characteristics and outcome data for overweight or obese children 2. Results on both general study sample and overweight/obese subsample have not yet been published 3. Sample size calculation: calculated for changes of anthropometric variables and running performance for total study sample 4. Funding source: Baden-Württemberg Stiftung gGmbH 	
Risk of bias		
Bias	Authors’ judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote (from email correspondence): “random sequence generation performed using a computer software”
Allocation concealment (selection bias)	Low risk	Quote (from email correspondence): “Schools were randomised at once”
Incomplete outcome data (attrition bias) All outcomes	High risk	Quote (from email correspondence): “Provided data are from a sub-sample of the total sample. Missing data were not imputed. Only completed baseline and follow-up data set were included in the analysis” Comment: no information available on characteristics of missing data
Selective reporting (reporting bias)	Low risk	Comment: Trial authors kindly provided unpublished data Quote (from email correspondence): “Data on mental flexibility cannot be provided to date because test of plausibility has not been performed yet”
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote (from email correspondence): “Children were not informed that the intervention might have a beneficial effect on cognitive function. Teachers, however, were informed that the intervention might improve cognitive function”
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote (from email correspondence): “Outcome assessor was blinded to experimental condition”

Comparability of baseline groups	Unclear risk	Quote (report): “[Stratified] randomisation based on number of classes in grade 1 and/or 2” Quote (from email correspondence): “Baseline groups did not differ in executive function and attention scores, ethnicity and obesity indices. Significant differences were detected for mean age (intervention group 7.22 years; control group 7.74 years) and gender distribution (intervention group: 60% boys; control group: 20% boys)”
Other bias	Low risk	Comment: none detected

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Bartholomew 2011	Study did not meet intervention criteria: Physical activity intervention was a short bout, three days of physically active lessons, which is too short to be considered as a lifestyle intervention for treatment of overweight and obesity
Chaya 2012	Study did not meet the control group criteria: The study used a physical activity control arm
Delgado-Rico 2012b	Study did not meet study design criteria: It followed a non-randomised, uncontrolled, pre/postintervention design
Epstein 2000	Study did not meet control group criteria: All experimental groups received family-based weight management treatment
Grieco 2009	Study did not meet study design criteria: It followed a non-randomised, uncontrolled, pre/postintervention design
Gunnarsdottir 2012b	Study did not meet study design criteria: It followed a non-randomised, uncontrolled, pre/postintervention design
Hill 2011	Study measured outcome during the intervention rather than at baseline and at end of intervention
Hollar 2010	Study did not meet design criteria: It followed a non-randomised cluster controlled design
Hutson 2008	Unclear whether study included overweight and obese children. Outcome data were not separately reported. Author's contact details not obtainable

(Continued)

Leidy 2013	Study measured school achievement and unrelated cognitive domains (appetite control and satiety regulation) using test tool not specified in this review (functional magnetic resonance imaging (fMRI) brain activation responses)
Milosis 2007	Primary outcome measure of school achievement was assessed through self reported grades
Reed 2012	Study did not meet study design criteria: It followed a non-randomised, pre/postintervention design
Robinson 2010	Primary outcome measure of school achievement was assessed through self reported grades
Tomporowski 2008	Study did not meet intervention criteria: Physical activity intervention was a short bout, one-off session of 23 minutes of treadmill walking, which is not considered a lifestyle intervention for treatment of overweight and obesity
Vanhelst 2012	Study did not meet study design criteria: It followed a non-randomised, uncontrolled, pre/postintervention design
Verbeken 2013	Study did not meet control group and lifestyle intervention criteria: Control group received same lifestyle intervention as intervention group. Intervention group played a computer game to train executive function, which was not considered an adequate lifestyle intervention according to our definition
Vos 2011	Secondary outcome measure of cognitive function was assessed as self perceived ability

Characteristics of studies awaiting assessment [ordered by study ID]

Coe 2006

Methods	Study design: randomised controlled cross-over trial Randomisation: Children were randomly assigned to one of four groups (two intervention and two control groups) Sequence generation: unplanned by administrators Allocation concealment: not reported Blinding: 1. Children: blinding to true purpose of the study not reported 2. Providers: blinding to true purpose of the study not reported 3. Outcome assessor: blinding not reported Duration of intervention: one school semester (five months) Follow-up: immediately postintervention Unit of analysis: child Inclusion/exclusion criteria: not reported Attrition: not separately reported for overweight and obese children Analysis: differences in outcome measures calculated using Kruskal-Wallis analysis with adjustments for child's physical activity level
Participants	N (recruited): not separately reported for overweight and obese children N (completed): not separately reported for overweight and obese children N (analysed): not separately reported for overweight and obese children

Coe 2006 (Continued)

	Age range: 10 to 12 years (sixth grade), mean age not reported for overweight and obese children Sex: not separately reported for overweight and obese children Ethnicity: not separately reported for overweight and obese children Geographical region: Michigan, USA
Interventions	Comparison: physical education versus control Intervention: physical education classes for 55 minutes on five days per week delivered by a physical education teacher Control: art or computer lessons
Outcomes	Outcome 1: School achievement: (1) average grades in mathematics and English obtained from school records. (2) Standardised assessment of reading or language arts and mathematics using the Terra Nova Outcome 2: Obesity indices: BMI calculated on basis of weight and height measurements. Criteria for classification of overweight and obesity status not reported
Notes	1. Authors were contacted to obtain outcome data for overweight and obese children 2. Funding sources: Blue Cross Blue Shield Foundation of Michigan, North American Society for Pediatric Exercise Medicine and Michigan State University College of Education and Graduate School

Donnelly 2009

Methods	Study design: cluster-randomised controlled trial Randomisation: Schools were randomly assigned to intervention and control groups stratified by school size and rural versus urban location Sequence generation: not reported Allocation concealment: not reported Blinding: 1. Children: blinding to true purpose of the study not reported 2. Providers: blinding to true purpose of the study not reported 3. Outcome assessor: yes Duration of intervention: three years Follow-up: immediately postintervention N schools recruited = 26 N schools completed = 24 (14 intervention schools, 10 control schools) Unit of analysis: child Inclusion criteria: not reported Attrition: not separately reported for overweight and obese children Analysis: adjusted <i>t</i> -test and linear mixed model with autoregressive type one covariance structure and compound symmetrical covariance adjusted for gender
Participants	N (recruited): not separately reported for overweight and obese children N (completed): not separately reported for overweight and obese children N (analysed): not separately reported for overweight and obese children Age: seven to nine years (second and third grades); mean age: not separately reported for overweight and obese children Sex: not separately reported for overweight and obese children Ethnicity: not separately reported for overweight and obese children Mean weight status at baseline: not separately reported for overweight and obese children

Donnelly 2009 (Continued)

	Geographical region: Kansas, USA
Interventions	<p>Comparison: classroom-based physical activity (Physical Activity Across the Curriculum-PAAC) versus standard care</p> <p>Intervention: Physically active academic lessons of moderate to vigorous intensity were provided for 90 minutes per week. Intervention was delivered by teachers intermittently throughout the school day in 10-minute bouts of physical activity in classrooms or at alternate school sites (hallways and outdoors)</p> <p>Standard care: usual school curriculum</p>
Outcomes	<p>Outcome 1: School achievement: Assessment of reading, writing, mathematics and oral language skills using the Wechsler Individual Achievement Test, 2nd Edition (WIAT II-A) administered by a trained psychologist blinded to the experimental condition</p> <p>Outcome 2: Obesity indices: (1) body mass index calculated on basis of weight and height measurements taken by trained researchers. Age- and gender-specific BMI percentiles were obtained using Centers for Disease Control and Prevention (CDC) 2000 growth charts</p>
Notes	<ol style="list-style-type: none"> 1. Authors were contacted to obtain separate characteristic and outcome data for overweight or obese children. Because of lack of personnel, the data could not be extracted 2. Power calculation: 26 schools provided 80% statistical power for detecting a true intervention effect of a two-unit increase in BMI for control children and a 1.5-unit increase in BMI for intervention children with a standard deviation of 1.5 and a moderate intraclass correlation of 0.1 3. Funding source: National Institutes of Health-National Institute of Diabetes and Digestive and Kidney Disease

Murray 2008

Methods	<p>Study design: cluster controlled trial</p> <p>N schools = eight</p> <p>Duration of intervention: one year</p> <p>Follow-up: after six months and 12 months</p> <p>Unit of analysis: child</p> <p>Analysis: growth curve analysis adjusted for ethnicity</p>
Participants	<p>N = 460 (165 overweight, 295 obese)</p> <p>Age range: nine to 11 years (third-fourth graders); mean age: not separately reported for overweight and obese children</p> <p>Sex: not separately reported for overweight and obese children</p> <p>Ethnicity: not separately reported for overweight and obese children</p> <p>Geographical region: Texas, USA</p>
Interventions	<p>Comparison: modified Take!10 programme on physical activity versus standard care</p> <p>Intervention: short physical activity sessions in the classroom of five to 20 minutes to meet total of 60 minutes/d, including physical education (PE) classes. Intervention was delivered by trained classroom teachers and PE teachers</p> <p>Standard care: usual co-ordinated school health programme (CATCH)</p>
Outcomes	<p>Outcome 1: School achievement: Mathematics problem-solving and reading comprehension scores were assessed using the Stanford 10 Achievement Test. Unclear whether the test was administered by a qualified person</p>
Notes	<ol style="list-style-type: none"> 1. Authors were contacted to obtain separate characteristic and outcome data for overweight or obese children 2. No full article/manuscript could be obtained; only a summary report was available 3. Funding source: not reported

Puder 2011

Methods	<p>Study design: cluster-randomised controlled trial</p> <p>Randomisation: Preschool classes were randomly assigned to intervention and control groups. Classes at the same school were allocated to the same group</p> <p>Sequence generation: method not reported, performed by a person from school health service</p> <p>Allocation concealment: using opaque envelopes</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinded to true purpose of the study 2. Providers: not blinded to true purpose of the study 3. Outcome assessor: yes <p>Duration of intervention: one academic year, i.e. 9.5 months (end of August to mid-June)</p> <p>Follow-up: immediately postintervention</p> <p>N classes = 40</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: prevalence of migrant children greater than 40%, no participation in other prevention project</p> <p>Attrition: not separately reported for overweight and obese children</p> <p>Analysis: mixed linear and logistic regression analysis based on intention-to-treat analysis. Adjustment of outcomes for clustering and baseline outcomes, sex, age and socio-cultural and linguistic regions</p>
Participants	<p>N (recruited): not separately reported for overweight and obese children</p> <p>N (included): 78 (35 in intervention group, 43 in control group)</p> <p>N (completed): not separately reported for overweight and obese children</p> <p>N (analysed): not separately reported for overweight and obese children</p> <p>Mean age: not separately reported for overweight and obese children</p> <p>Sex: not separately reported for overweight and obese children</p> <p>Ethnicity: not separately reported for overweight and obese children</p> <p>Geographical region: German and French speaking regions of Switzerland</p>
Interventions	<p>Comparison: multicomponent lifestyle intervention versus standard care</p> <p>Interventions: involvement of children, teacher and parents. Adaptation of build environment</p> <ol style="list-style-type: none"> 1. Physical activity: exercise classes focusing on aerobic fitness and co-ordination skill development in four 45-minute sessions per week. Physical activity groups were delivered in the classroom and once per week in the gymnasium by the school teacher and a health promoter (once per week during the first four months and twice per month afterwards). Children received twice per month a physical activity task to take home. Adaptation of classroom and school environment to promote physical activity during recess (e.g. installation of climbing walls and hammocks and provision of balls, cords and stilts) 2. Diet/nutrition: nutrition education classes-22 sessions based on recommendations of the Swiss Society of Nutrition. Children received twice per month a nutrition activity card to take home. Teachers were encouraged to provide only healthy food and snacks and water 3. Media use: education classes-22 sessions over the intervention period <p>Standard care: continuation of usual school curriculum, which included 45 minutes of physical education per week</p>
Outcomes	<p>Outcome 1: Cognitive function: (1) assessment of attention using the “Testing manual for concentration assessment in preschool children” by Ettrich and Ettrich. (2) Assessment of spatial working memory using the Intelligence and Development Scales (IDS) of Grob et al</p> <p>Outcome 2: Obesity indices: (1) Body mass index was calculated on the basis of weight and height measurements. Overweight status was defined as BMI \geq 90th centile based on IOTF classification. (2) Percentage body fat was assessed using bioelectrical bioimpedance analysis. Validated formula by Schoefer et al was used to calculate percentage body fat. (3) Waist circumference was measured “with a flexible tape midway between iliac crest and the lowest border of the rib cage”</p>

Puder 2011 (Continued)

Notes	<ol style="list-style-type: none"> 1. Authors were contacted to obtain separate characteristic and outcome data for overweight or obese children 2. Power calculation: 40 classes provide 90% statistical power for detecting a true intervention effect of 0.5 standard deviation between participants at the significance level of 0.05, provided that the standard deviation of the random class effect does not exceed 25% of the standard deviation between participants 3. Funding sources: Swiss National Science Foundation, Health Promotion Switzerland, University of Lausanne, Takeda Research Award, Wyeth Foundation for the Health of Children and Adolescents, Freie Akademische Gesellschaft, Nestlé (unrestricted educational grant)
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Reed 2010

Methods	<p>Study design: randomised controlled trial</p> <p>Sequence generation: not reported</p> <p>Allocation concealment: not reported</p> <p>Unit of allocation: classrooms</p> <p>N classrooms = six (three intervention classrooms, three control classrooms)</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinded to true purpose of the study 2. Providers: not possible in physical activity intervention 3. Outcome assessor: unclear <p>Duration of intervention: 12 weeks</p> <p>Follow-up: immediately after intervention</p> <p>Unit of analysis: child</p> <p>Attrition: not separately reported for overweight and obese children</p> <p>Analysis: multivariate analysis, no adjustment for confounders</p>
Participants	<p>N (randomised) = not separately reported for overweight and obese children</p> <p>N (completed) = not separately reported for overweight and obese children</p> <p>N (analysed) = 26</p> <p>Age range: eight years</p> <p>Sex: not separately reported for overweight and obese children</p> <p>Ethnicity: not separately reported for overweight and obese children</p> <p>Inclusion/exclusion criteria: not reported</p> <p>Geographical region: South Carolina, USA</p>
Interventions	<p>Comparison: physical activity versus standard care</p> <p>Intervention: integration of physical activity into core curricula (e.g. language arts, mathematics, social studies) for 30 minutes per day on three days per week over 12 weeks in total. Physical activity included activities to build fundamental skills such as walking, hopping and running. Intervention was delivered by trained classroom teachers. Compliance was assessed in random audits by direct observation</p> <p>Standard care: traditional classroom without integrated physical activity</p>
Outcomes	<p>Outcome 1: School achievement: assessment of English/language arts, mathematics levels (below basic, basic, proficient, advanced) using the Palmetto Achievement Challenge Tests (PACT). The test was administered by trained personnel contracted by the South Carolina Department of Education. Scoring was performed using computer programming</p> <p>Outcome 2: Cognitive function: assessment of educative components of general intelligence and cognitive ability using the Standard Progressive Matrices (SPM) Fluid Intelligence Test. Five sets of questions were assessed and reported as total scores. Unclear whether the test was administered by a qualified and trained person</p>

Reed 2010 (Continued)

	Outcome 3: Obesity indices: body mass index calculated using FITNESSGRAM® based on measured weight and height
Notes	<ol style="list-style-type: none"> 1. Authors contacted to obtain data on overweight/obese participants. Data will be provided for review revision phase 2. No sample size calculation was performed. Thus, this study might be at risk for a type two error 3. Funding sources: none reported

Telford 2012

Methods	<p>Study design: non-randomised cluster controlled trial</p> <p>Allocation concealment: not reported</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinding to true purpose of the study not reported 2. PCroviders: blinding to true purpose of the study not reported 3. Outcome assessor: blinding not reported <p>Duration of intervention: two years</p> <p>Follow-up: immediately postintervention</p> <p>N schools randomly assigned = 48 schools (68 classes) (13 intervention schools [32 classes], 16 control schools [36 classes])</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: not reported</p> <p>Attrition: not separately reported for overweight and obese children</p> <p>Analysis: multilevel models adjusted for effects of variation between baseline measurements and follow-up measures, gender, physical activity, cardiorespiratory fitness and percentage body fat. Adjustment for random school effect to account for a possible cluster effect on outcomes</p>
Participants	<p>N (recruited): not separately reported for overweight and obese children</p> <p>N (completed): not separately reported for overweight and obese children</p> <p>N (analysed): not separately reported for overweight and obese children</p> <p>Age: eight to nine years (third grade); mean age: not separately reported for overweight and obese children</p> <p>Sex: not separately reported for overweight and obese children</p> <p>Ethnicity: not separately reported for overweight and obese children</p> <p>Mean weight status at baseline: not separately reported for overweight and obese children</p> <p>Geographical region: Australia</p>
Interventions	<p>Comparison: specialist-taught physical education (PE) versus standard care</p> <p>Intervention: PE for 45 to 50 minutes per week (two sessions/wk) taught by a specialised physical education teacher, in addition to commonly taught PE sessions delivered two to three times for 50 to 60 minutes per week. Specialist-taught PE employed minor games and group activities; emphasised strength, balance and postural control; and encouraged discussions on skill development strategies</p> <p>Standard care: commonly practiced PE programme</p>
Outcomes	<p>Outcome 1: School achievement: Baseline literacy and mathematics were assessed by teachers who administered tests designed and assessed by the government education authority. Baseline measures were taken two months after start of the intervention. Follow-up assessments were “the responsibility of the Australian Curriculum, Assessment and Reporting Authority”</p> <p>Outcome 2: Obesity indices: (1) Body mass index calculated on basis of weight and height measurements. Unclear</p>

Telford 2012 (Continued)

	who performed measurements. (2) Percentage body fat assessed using dual-energy x-ray absorptiometry (DEXA)
Notes	<ol style="list-style-type: none"> 1. Authors were contacted to obtain separate characteristic and outcome data for overweight or obese children 2. Schools were matched on the basis of socioeconomic status of school and average family income, facilities, general administration, governmentally funded and teaching methods 3. Power calculation: not reported 4. Funding source: Commonwealth Education Trust (London, UK)

Characteristics of ongoing studies [ordered by study ID]

Accacha 2012

Trial name or title	Insulin resistance and cognitive dysfunction in obese adolescents: pilot study
Methods	<p>Study design: randomised controlled trial</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: no 2. Providers: no 3. Outcome assessor: no <p>Duration of intervention: six months</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: male and female participants 14 to 19 years of age, BMI > 99th centile, clearance by paediatric cardiologist (including evaluation of VO2max)</p> <p>Exclusion criteria: younger than 14 years of age and older than 19 years, youth with type one or type one diabetes, serious medical conditions, no clearance by cardiologist</p> <p>Sample size calculation: not provided</p>
Participants	<p>N estimated = 50</p> <p>Age: 14 to 19 years</p> <p>BMI > 99th centile corrected for age</p> <p>Geographical region: New York, USA</p>
Interventions	<p>Comparison: exercise versus wait list control</p> <p>Intervention: exercise programme, no further details provided</p>
Outcomes	Outcome 1: Cognitive function: change in neurocognitive function, no further details provided
Starting date	December 2012
Contact information	Siham Accacha (saccacha@winthrop.org), Pediatric Endocrinology and Metabolism, Winthrop University Hospital
Notes	Estimated study completion date: June 2014

Andersen 2012

Trial name or title	The Odense Overweight Intervention Study (OOIS)
Methods	<p>Study design: randomised controlled trial</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: no 2. Providers: no 3. Outcome assessor: yes <p>Duration of intervention: six weeks</p> <p>Follow-up measurements: immediately after intervention and 12 months after intervention</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: children in the municipality of Odense, Denmark, who were overweight or obese according to IOTF cutoffs</p> <p>Exclusion criteria: participation in other studies related to risk factors of heart disease, children who follow a special school programme, use of weight-reducing medicine within three months before baseline measurements, children with motor skill conditions that hinder participation in the intervention</p> <p>Sample size calculation: not provided</p>
Participants	<p>Estimated N = 100</p> <p>Age: 10 to 13 years</p> <p>Geographical region: Odense, Denmark</p>
Interventions	<p>Comparison: OOIS intervention camp versus standard care</p> <p>Intervention: participation in a six-week day camp providing social activities, physical activity training, usual school classes</p> <ol style="list-style-type: none"> 1. Physical activity: three hours/d, no further information provided 2. Behaviour change: health education, no further information provided 3. Diet/Nutrition: healthy meals provided throughout the camp <p>Standard care: weekly one-hour physical activity sessions over six weeks for children. Two information sessions on diet and exercise for parents</p>
Outcomes	<p>Outcome 1: Cognitive function: change in cognitive function measured using the Stroop Color and Word Test, the Trail Making Test (parts A and B), the Rey Complex Figure Test and Recognition Trial, the Symbol Digit Modalities Test and the Behaviour Rating Inventory of Executive Function</p> <p>Outcome 2: Obesity indices: change in BMI based on measured weight and height, change in fat mass measured using DEXA, change in waist/hip circumference: Waist circumference will be measured between the lower costal margin and the lilac crest; hip circumference will be measured at the level of the greater trochanter</p>
Starting date	April 2012
Contact information	Professor Lars Bo Andersen, Center of Research in Childhood Health (RICH), University of Southern Denmark, Odense, Funen, 5230, Denmark
Notes	Estimated study completion date: July 2017

Damsgaard 2012

Trial name or title	The OPUS School Meal Study
Methods	<p>Study design: cluster-randomised controlled cross-over trial</p> <p>Randomisation: Schools were randomly assigned to intervention and control groups stratified by year and group (grade three or four)</p> <p>Sequence generation: by R statistical software</p> <p>Allocation concealment: not reported</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: blinding not reported 2. Providers: blinding to true purpose of the study not reported 3. Outcome assessor: blinding not reported <p>Duration of intervention: three months</p> <p>Follow-up: immediately postintervention at three months (first iteration) and six months (after cross-over period)</p> <p>N schools = nine schools (46 classes)</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: school located in eastern part of Denmark, four classes in grades three and four, suitable kitchen facilities, high motivation for participation</p> <p>Exclusion criteria: disease or condition that obstructs measurements or puts children at risk if eating the diet, contaminates participation in other scientific studies involving radiation or blood sampling</p>
Participants	<p>N (recruited): 114 (98 overweight, 16 obese)</p> <p>N (completed): not separately reported for overweight and obese children</p> <p>N (analysed): not separately reported for overweight and obese children</p> <p>Age: nine to 11 years (third and fourth grades); mean age: not separately reported for overweight and obese children</p> <p>Sex: not separately reported for overweight and obese children</p> <p>Ethnicity: not separately reported for overweight and obese children</p> <p>Geographical region: Denmark</p>
Interventions	<p>Comparison: diet based on New Nordic Diet versus standard care</p> <p>Intervention: daily serving of a mid-morning snack, ad libitum hot lunch meal and afternoon snack and dessert twice/wk meeting 40% to 45% of daily energy intake based on energy requirements of 11-year-old children. Children participated in cooking every day. Increase in school lunch breaks from 15 minutes to 20 to 25 minutes. The New Nordic Diet contains seasonal, health-promoting ingredients, for example, berries, root vegetables, whole grains, fish, shellfish, seaweed and rapeseed oil. Diet contains less meat than average Danish diet</p> <p>Standard care: usual packed lunch</p>
Outcomes	<p>Outcome 1: School achievement: teacher-assessed mathematics and reading proficiency using age-specific Danish standardised tests</p> <p>Outcome 2: Cognitive function: assessment of attention using the D2 Test of Attention. Unclear who administered the test</p> <p>Outcome 3: Obesity indices: BMI z-score generated on the basis of weight and height measurements. Classification of overweight or obese weight category based on IOTF definition</p>
Starting date	2011

Damsgaard 2012 (Continued)

Contact information	Camilla T. Damsgaard (ctd@life.ku.dk), Department of Human Nutrition, Faculty of Science, University of Copenhagen
Notes	<ol style="list-style-type: none"> 1. Authors contacted to obtain data for overweight or obese subgroup 2. Power calculation performed for total study sample based on metabolic syndrome test score 3. Funding source: Nordea Foundation

Donnelly 2012

Trial name or title	Physical activity and academic achievement across the curriculum (A+PAAC)
Methods	<p>Study design: randomised controlled trial</p> <p>Duration of intervention: three years</p> <p>Unit of allocation: school</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: grade two or three students of randomly selected elementary schools, agreement to assessments, signed parental consent form and signed child assent form</p> <p>Sample size calculation: not reported</p>
Participants	<p>N estimated = 640</p> <p>Age: seven to 10 years</p>
Interventions	<p>Comparison: regular sedentary lessons</p> <p>Intervention: academic lessons delivered by regular classroom teacher using moderate to vigorous physical activity for 20 minutes/d, five days/wk</p>
Outcomes	<p>Outcome 1: School achievement: changes in academic achievement, no further details provided</p> <p>Outcome 2: Cognitive function: attention control, attention-to-task, no further details provided</p> <p>Outcome 3: Assessment of weight status: changes in body mass index, no further details provided</p>
Starting date	September 2011
Contact information	Joseph E. Donnelly, University of Kansas, Medical Centre Research Institute, jdonnelly@ku.edu
Notes	Estimated completion date: June 2014

Martinez-Vizcaino 2012

Trial name or title	MOVI-2 Program
Methods	<p>Study design: cluster-randomised controlled study</p> <p>Unit of randomisation: schools</p> <p>N schools = 10 intervention, 10 control</p> <p>Duration of intervention: one academic year</p> <p>Follow-up: immediately after intervention and nine months postintervention</p> <p>Unit of analysis: child</p>

Martinez-Vizcaino 2012 (Continued)

	<p>Inclusion criteria: literate in Castilian Spanish, absence of physical or mental disorders identified by teachers or parents, which would prevent intervention participation; absence of chronic disease diagnosed by paediatrician or general practitioner that is considered to prevent intervention participation, involvement of family member</p> <p>Sample size calculation: based on total sample, 600 children/group, to show a difference of 2% ± 6% (alpha = 0.05, power = 0.80) between experimental groups in mean body fat considering an inflation factor for cluster randomisation of 1.05 and analysis of results by four groups (by age, sex, weight, experimental condition)</p> <p>Statistical analysis: mixed regression models adjusted for baseline values, age, school applying intention-to-treat analysis</p>
Participants	<p>N (randomly assigned) = 1592 (N intervention = 823, N control = 769)</p> <p>N (included) = 1070 (N intervention = 581, N control = 489)</p> <p>Age: 10 to 13 years (fourth and fifth grades)</p> <p>Geographical region: Cuenca, Spain</p>
Interventions	<p>Comparison: physical activity (MOVI-2 programme) versus standard care</p> <p>Intervention: 80 sessions of play-based, non-competitive physical activity including basic sport games, popular and traditional games, alternative games and activities in the natural environment twice per week for 90 minutes on weekdays and 150 minutes on weekend days. Average energy expenditure during physical activity session is 4.17 kcal/min; average heart rate in 151 bpm</p> <p>Standard care: usual physical activity in school</p>
Outcomes	<p>Outcome 1: School achievement: final grades obtained from school records. Further details not provided</p> <p>Outcome 2: Obesity indices: waist circumference measured three times at midpoint between last rib and iliac crest at the end of a normal expiration using a flexible tape, percentage body fat obtained through bioimpedance monitoring</p>
Starting date	September 2010
Contact information	Vicente Martínez-Vizcaíno (Vicente.Martinez@uclm.es), Universidad de Castilla-La Mancha, Edificio Melchor Cano, Centro de Estudios Socio-Sanitarios, Santa Teresa Jornet s/n, 16071 Cuenca, Spain
Notes	<ol style="list-style-type: none"> 1. Funding source: Ministry of Education and Science of the Junta of Communities of Castile-La Mancha, FIS grant, Research Network on Preventative Activities and Health Promotion 2. Author reported that findings for overweight/obese children are submitted for publication

Pentz 2011

Trial name or title	The Pathway Trial
Methods	<p>Study design: cluster-randomised controlled</p> <p>Unit of randomisation: schools</p> <p>N schools = 28</p>
Participants	<p>N (included) = 1002</p> <p>Age: 10 to 11 years (fourth grade)</p> <p>Gender: 52% female</p> <p>Geographical location: Los Angeles, USA</p>

Pentz 2011 (Continued)

Interventions	<p>Comparison: behaviour change versus standard care</p> <p>Intervention: 15 teacher-led sessions on executive function skills applied to emotional regulation and impulse control over eating and physical activity</p> <p>Standard care: usual school routine</p>
Outcomes	<p>Outcome 1: Cognitive function: executive function, no further details could be obtained</p> <p>Outcome 2: Obesity indices: BMI based on measured weight and height, waist circumference</p>
Starting date	Could not be obtained
Contact information	Professor Mary Ann Pentz (pentz@usc.edu), Institute for Health Promotion and Disease Prevention Research, Keck School of Medicine, University of Southern California 2001 N. Soto Street, Ste. 302H, MC 9239, Los Angeles, CA 90032
Notes	Author reported that findings for overweight/obese children are submitted for publication

Robinson 2012

Trial name or title	Clinic Family & Community Collaboration to Treat Overweight and Obese Children (Stanford GOALS)
Methods	<p>Study design: randomised controlled trial</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: no 2. Provided: no 3. Outcome assessor: yes <p>Duration of intervention: three years</p> <p>Follow-up measurements: after one, two and three years</p> <p>Unit of allocation: school</p> <p>Unit of analysis: child</p> <p>Inclusion criteria: children seven to 11 years of age, BMI \geq 85th percentile for age and gender on the 2000 CDC BMI reference</p> <p>Exclusion criteria: child diagnosed with a medical condition affecting growth (e.g. type one diabetes, chronic gastrointestinal disease, chronic renal disease, heart condition), pregnancy, taking type two diabetes medication, taking medication affecting growth, with conditions limiting participation in the intervention (e.g. physical disability) and assessment (e.g. insufficient English or Spanish reading and writing competency), unable to understand and complete consent forms, intention to move from San Francisco Bay Area within the next 36 months</p> <p>Sample size calculation: not reported</p>
Participants	<p>Estimated N = 240</p> <p>Age: seven to 11 years</p> <p>Geographical region: California, USA</p>
Interventions	<p>Comparison: multicomponent, multilevel, multisetting intervention versus enhanced standard care health education</p> <p>Intervention: large-scale, community-based, interdisciplinary, multicomponent, multisetting intervention</p> <ol style="list-style-type: none"> 1. Physical activity: community team sports programme designed specifically for overweight and obese children; no further details on duration, intensity, frequency and type of sport reported

Robinson 2012 (Continued)

	<p>2. Behaviour change: behavioural counselling delivered by primary care provider, home-based family intervention to reduce screen time, alter food/eating environment and promote self regulatory skills for eating and activity behaviour change; no further details on duration and frequency provided</p> <p>Standard care: health and nutrition education-semiannual home counselling visits, monthly health education newsletter for children and parents/carers, quarterly community-based evening health lectures</p>
Outcomes	<p>Outcome 1: School achievement: no details reported</p> <p>Outcome 2: Obesity indices: body mass index, waist circumference, triceps skinfold thickness, waist-to-hip ratio; no further details provided</p>
Starting date	July 2012
Contact information	Dr Donna Matheson, donna.matheson@stanford.edu, Stanford University, Palo Alto, California, United States 94304
Notes	Estimated study completion date: April 2017

Tompkins 2012

Trial name or title	Effect of an unstructured, moderate to vigorous, before-school physical activity program in elementary school children on academics, behaviour, and health
Methods	<p>Study design: randomised controlled trial</p> <p>Randomisation: allocation of participants to intervention groups on a first-come first-serve basis of participation response. Allocation to control group when N = 50 is reached in intervention group</p> <p>Allocation concealment: notification of allocation by mail after consent for participation was given</p> <p>Blinding:</p> <ol style="list-style-type: none"> 1. Children: no 2. Providers: not reported 3. Outcome assessor: not reported <p>Duration of intervention: 12 weeks</p> <p>Follow-up: immediately postintervention</p> <p>Unit of allocation: child</p> <p>Unit of analysis: child</p> <p>Inclusion/exclusion criteria: not reported</p> <p>Sample size calculation: total required sample size N = 42 with N = 21 per group based on anticipated effect size of 0.8 and statistical power set at 0.8 with a significance level of 0.05</p>
Participants	<p>N to be recruited = 50 per group</p> <p>Age: seven to 11 years (third to fifth grade)</p>
Interventions	<p>Comparison: physical activity versus no treatment</p> <p>Intervention: physical activity programme for 12 weeks, three days a week, in a school setting. Children choose preferred activities but are encouraged to maintain individually determined heart rate, indicating moderate to vigorous activity ranging from 120 beats per minute (bpm) to 180 bpm. Activities include, for example, walking, jogging, running, football, jump rope and basketball</p>

Tompkins 2012 (Continued)

Outcomes	<p>Baseline measurements are performed one to two weeks before the first physical activity session. Follow-up measures will be taken within one week after the final physical activity session</p> <p>Outcome 1: School achievement: teacher assessed through grades, achievement test scores and progress monitoring via curriculum-based measures. School subjects for grade and achievement test score assessment not reported. Curriculum-based measures assessed basic mathematics skills (number operations) and oral fluency skills (e.g. progress comprehension, reading, vocabulary, phonics) using M-COMP and Oral Fluency Measure</p> <p>Outcome 2: Assessment of weight status: BMI calculations based on weight and height measurements. Whether age- and gender-specific BMI will be calculated and whether classification of obesity status will be performed remained unreported. Waist and hip measurements are taken</p>
Starting date	Not reported
Contact information	Correspondence: Connie.Tompkins@uvm.edu , Department of Rehabilitation & Movement Science, University of Vermont, 106 Carrigan Drive, 310D Rowell, Burlington, VT 05405-0068, USA
Notes	Funding source: none reported

DATA AND ANALYSES

Comparison 1. Lifestyle interventions versus standard care

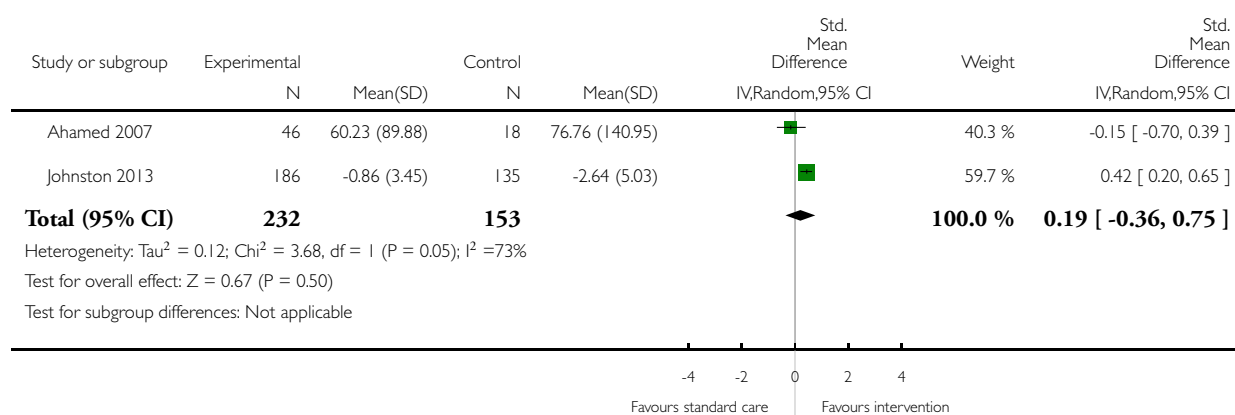
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Overall school achievement	2	385	Std. Mean Difference (IV, Random, 95% CI)	0.19 [-0.36, 0.75]
2 Mathematics achievement	2	160	Std. Mean Difference (Random, 95% CI)	17.94 [-18.44, 54.32]
3 Language achievement	1	64	Mean Difference (Random, 95% CI)	27.97 [-5.35, 61.29]
4 Reading achievement	2	160	Std. Mean Difference (Random, 95% CI)	0.07 [-2.14, 2.28]
5 Vocabulary achievement	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
6 Attention	2	143	Std. Mean Difference (IV, Random, 95% CI)	-0.25 [-0.92, 0.41]
7 Executive function	2	170	Mean Difference (IV, Random, 95% CI)	3.42 [0.62, 6.22]
8 Inhibitory control	1	18	Mean Difference (IV, Random, 95% CI)	0.26 [-1.27, 1.79]
9 Working memory	1	116	Mean Difference (IV, Random, 95% CI)	3.0 [0.51, 5.49]
10 Simultaneous processing	1	116	Mean Difference (IV, Random, 95% CI)	1.0 [-2.19, 4.19]
11 BMI z-score	2	437	Mean Difference (IV, Random, 95% CI)	0.03 [-0.15, 0.21]
12 BMI SD-score	1	30	Mean Difference (IV, Random, 95% CI)	0.34 [-0.01, 0.69]
13 BMI centile	1	30	Mean Difference (IV, Random, 95% CI)	2.26 [-0.86, 5.38]

Analysis 1.1. Comparison 1 Lifestyle interventions versus standard care, Outcome 1 Overall school achievement.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 1 Overall school achievement

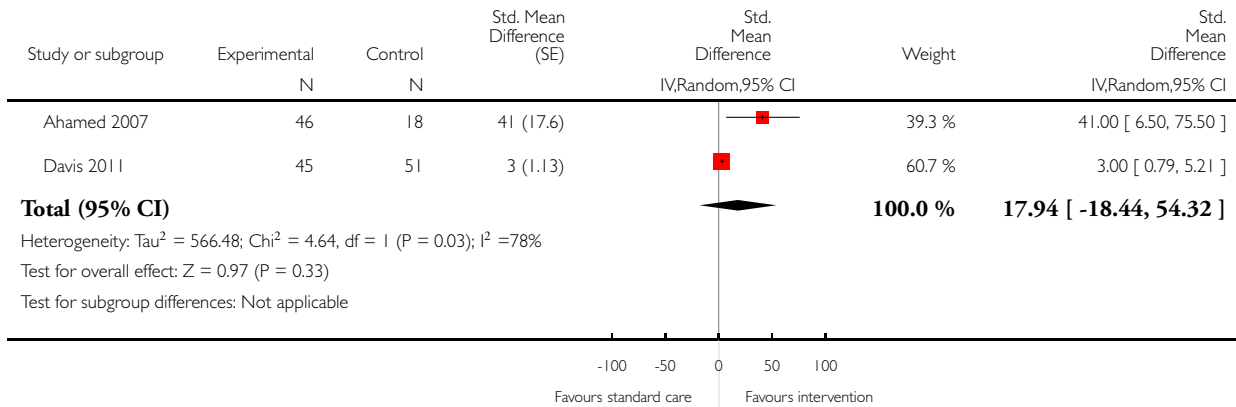


Analysis 1.2. Comparison 1 Lifestyle interventions versus standard care, Outcome 2 Mathematics achievement.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 2 Mathematics achievement

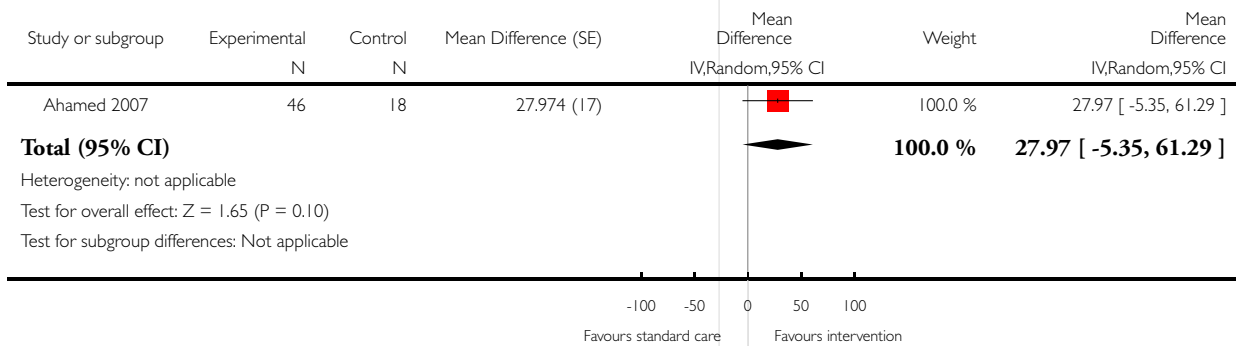


Analysis 1.3. Comparison 1 Lifestyle interventions versus standard care, Outcome 3 Language achievement.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 3 Language achievement

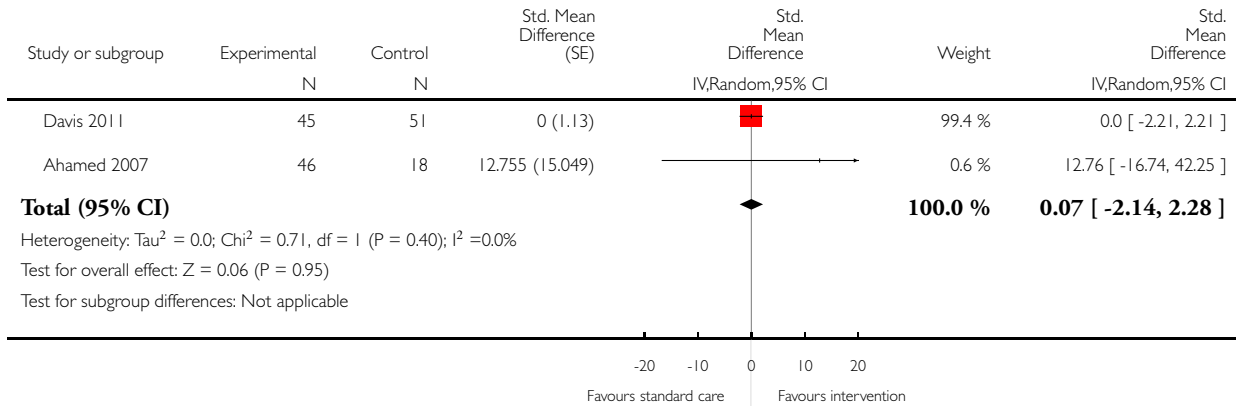


Analysis 1.4. Comparison 1 Lifestyle interventions versus standard care, Outcome 4 Reading achievement.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 4 Reading achievement

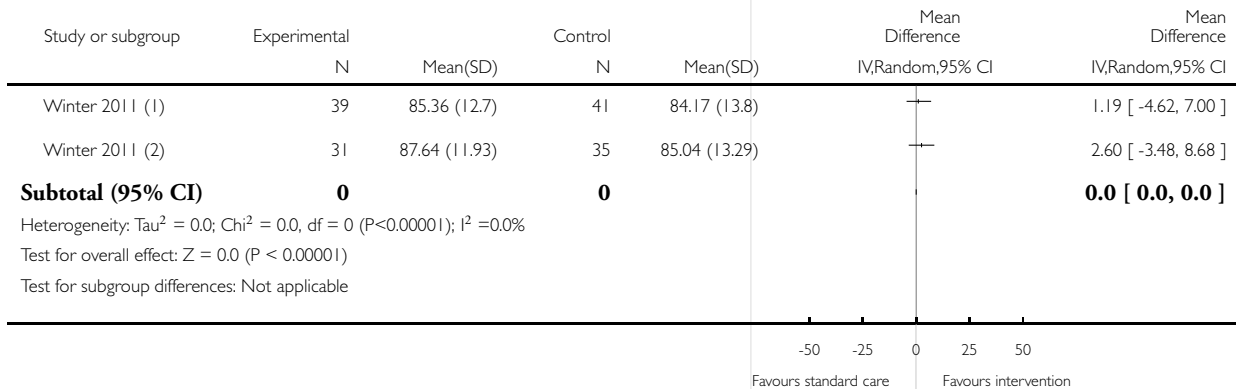


Analysis 1.5. Comparison 1 Lifestyle interventions versus standard care, Outcome 5 Vocabulary achievement.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 5 Vocabulary achievement



(1) missing data imputed (LOCF)

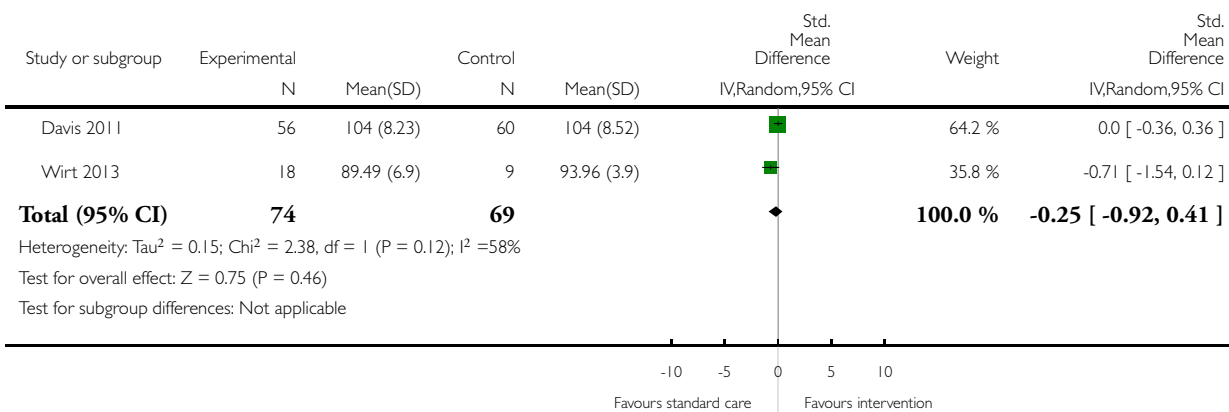
(2) complete data set without imputation of missing data

Analysis 1.6. Comparison 1 Lifestyle interventions versus standard care, Outcome 6 Attention.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 6 Attention

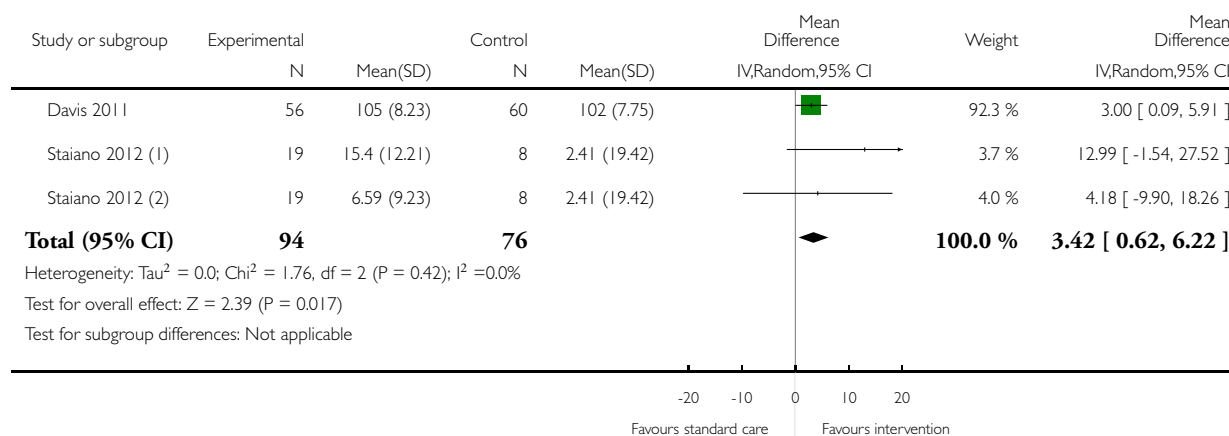


Analysis 1.7. Comparison 1 Lifestyle interventions versus standard care, Outcome 7 Executive function.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 7 Executive function



(1) competitive exergaming condition versus control

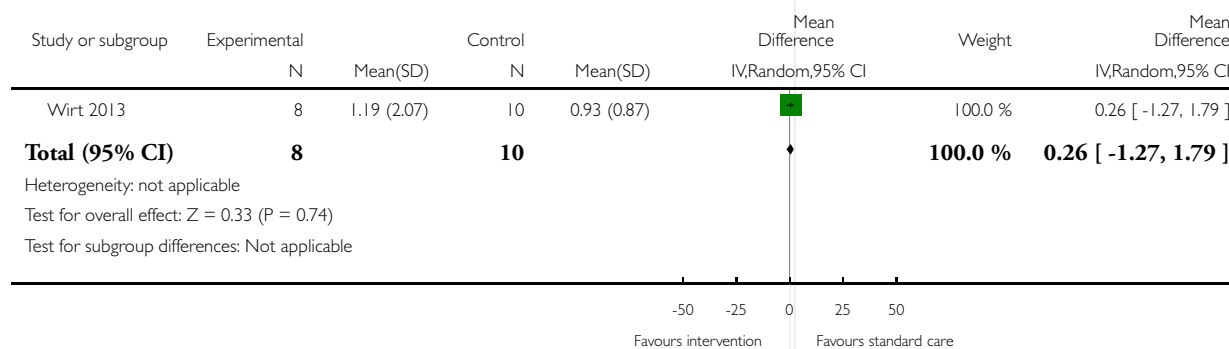
(2) cooperative exergaming condition versus control

Analysis 1.8. Comparison 1 Lifestyle interventions versus standard care, Outcome 8 Inhibitory control.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 8 Inhibitory control

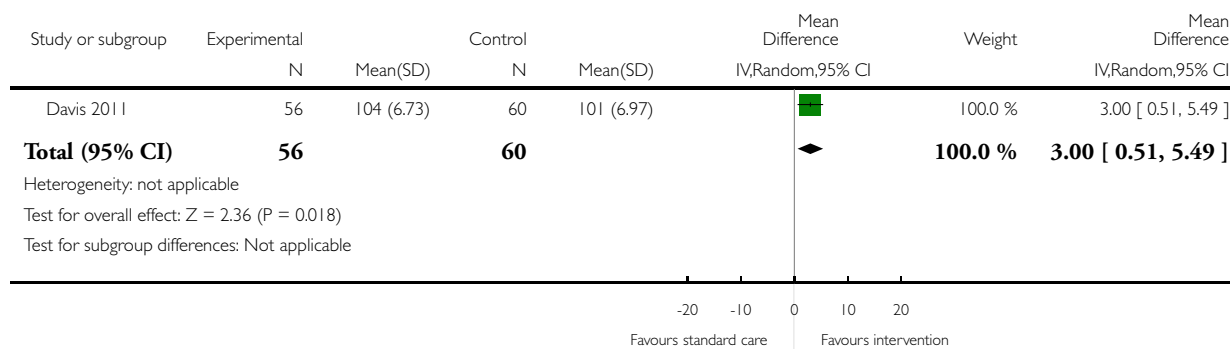


Analysis 1.9. Comparison 1 Lifestyle interventions versus standard care, Outcome 9 Working memory.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 9 Working memory

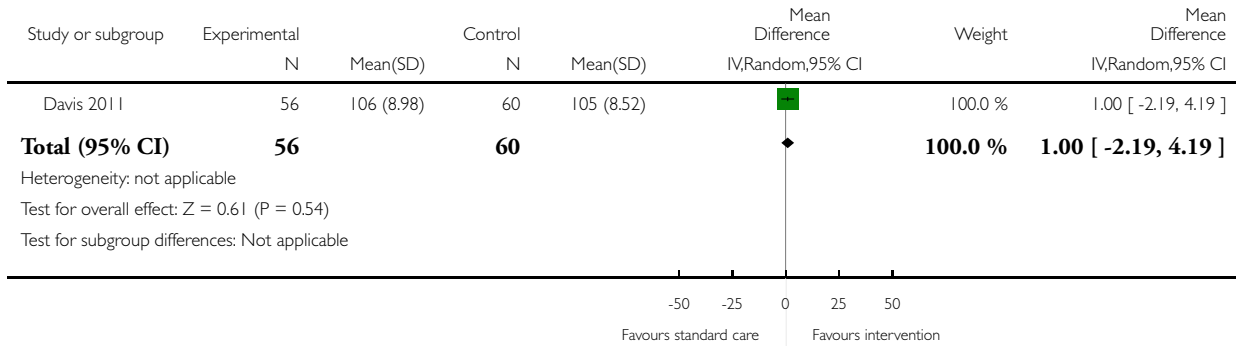


Analysis 1.10. Comparison 1 Lifestyle interventions versus standard care, Outcome 10 Simultaneous processing.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 10 Simultaneous processing

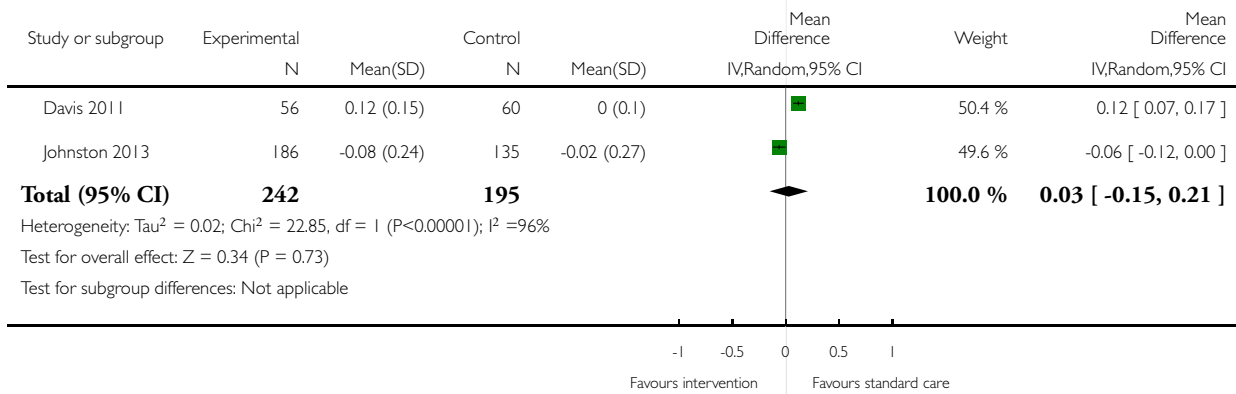


Analysis 1.11. Comparison 1 Lifestyle interventions versus standard care, Outcome 11 BMI z-score.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 11 BMI z-score

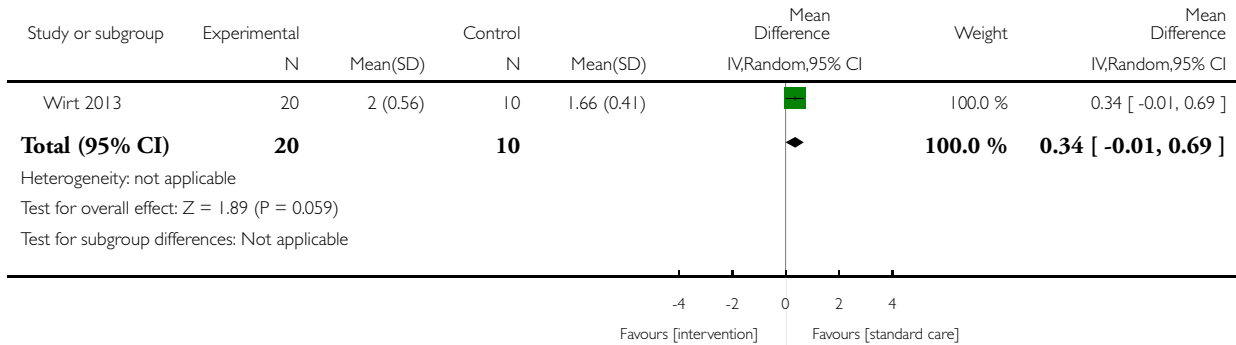


Analysis 1.12. Comparison 1 Lifestyle interventions versus standard care, Outcome 12 BMI SD-score.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 12 BMI SD-score

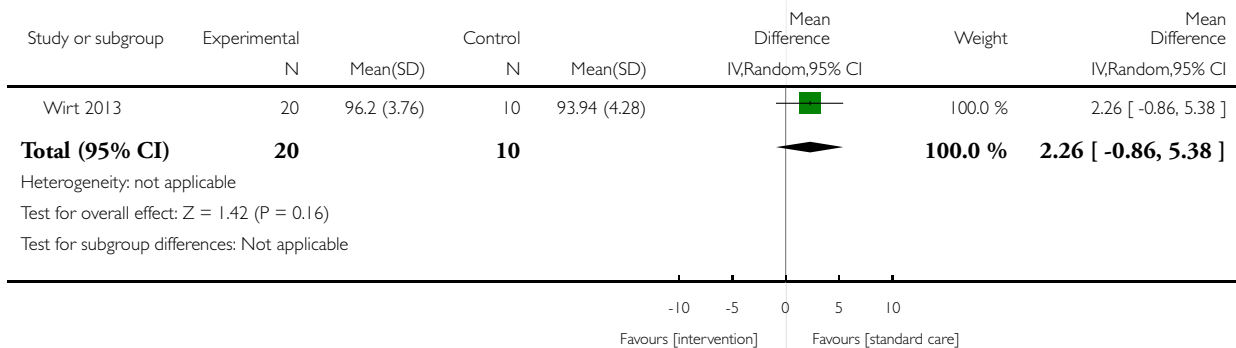


Analysis 1.13. Comparison 1 Lifestyle interventions versus standard care, Outcome 13 BMI centile.

Review: Lifestyle intervention for improving school achievement in overweight or obese children and adolescents

Comparison: 1 Lifestyle interventions versus standard care

Outcome: 13 BMI centile



ADDITIONAL TABLES

Table 1. Additional methods

Method item	Additional methods
Measures of treatment effect	<p>For dichotomous data, outcomes will be summarised as a risk ratio (RR) with a 95% confidence interval (CI). Using risk ratio rather than odds ratio minimises misinterpretation of the occurrence of the treatment effect and avoids subsequent conversion of odds ratios to risk ratios for correct interpretation. In the ‘Summary of findings’ table, we will express dichotomous data as relative (risk ratio) and absolute (number of children per 1000) risk</p> <p>For ordinal data, we will analyse longer ordinal scales (e.g. Wechsler Intelligence Scale for Children) as continuous data (Higgins 2011). When studies use short ordinal scales (e.g. A to F classification of educational achievement), we will convert these to dichotomous data by combining adjacent categories and calculating the risk ratio (Higgins 2011). Dichotomisation will be done according to the cutoffs considered as ‘pass’ or ‘fail’</p>
Unit of analysis issues	<p>Cross-over trials. We will include data only from the first period and will treat the data as derived from a parallel-group trial in which participants were allocated to a single intervention. Data from subsequent iterations are prone to bias, for example, carry-over effects. We planned to conduct a sensitivity analysis to examine the robustness of the results, including data from cross-over trials</p> <p>Multiple time points. We will analyse data from studies that reported results at more than one time point in a separate meta-analysis with comparable data from other studies at similar time points. We will group postintervention time points as immediately after intervention, one to five months, six to 11 months, 12 to 23 months and ≥ 24 months after intervention</p>
Assessment of reporting biases	<p>Reporting bias will be assessed by using a funnel plot to evaluate the association between effect size and standard error, if a sufficient number of studies (at least 10 studies) are included in the review. An asymmetrical plot may indicate publication bias or a real relationship between study size and effect size, as when larger trials have lower compliance rates and compliance is positively related to effect size. If we find such a relationship, we will explore clinical variation as a possible explanation. When the number of included studies is low, an asymmetrical funnel plot may be due to heterogeneity in the intervention effect or chance</p>
Synthesis of continuous and dichotomous data	<p>If similar outcome data are extracted as both dichotomous and continuous measures (e.g. exam results expressed as pass or fail or as a percentage score), we used the inverse variance method to combine data; to do this, we converted the risk ratio to lnRR and standard error (SE) of lnRR for entry into Review Manager 5.2</p>

Table 1. Additional methods (Continued)

<p>Subgroup analysis and investigation of heterogeneity</p>	<p>Subgroup analyses within this review are intended to focus on the following</p> <p>Participant characteristics</p> <ol style="list-style-type: none"> 1. Age (preschool vs primary or elementary school vs secondary or high school) 2. Gender (male vs female) 3. Weight status (overweight vs obese) 4. Location (low- and middle-income countries vs high-income countries) <p>Study design characteristics</p> <ol style="list-style-type: none"> 1. Setting (home vs clinic vs school vs community) 2. Intervention duration (< six months vs ≥ six months) 3. Type of intervention (single component vs multicomponent; energy balance intervention vs behavioural intervention) 4. Type of outcome assessment (formal educational assessment vs non-formal assessment (e.g. research only data)) <p>These subgroups are exploratory because they are based on non-experimental conditions (cross-sectional studies); large numbers of subgroup analyses may lead to misleading conclusions (Yusuf 1991; Oxman 1992). Therefore, when performing subgroup analyses, we will treat any conclusions with caution</p>
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APPENDICES

Appendix I. Search strategies

Cochrane Central Database of Controlled Trials (CENTRAL)

2012 Issue 2 searched on 2 March 2012 [2145 records]

2013 Issue 4 searched on 8 May 2013. Limited to publication year = 2012 to 2013 [98 records]

- #1 MeSH descriptor Overweight explode all trees
- #2 MeSH descriptor Body Weight, this term only
- #3 (obes* or overweight or over-weight)
- #4 MeSH descriptor Body Weight Changes explode all trees
- #5 (weight near/2 (loss or lost or losing or reduc*))
- #6 (weight near/2 (gain* or increas*))
- #7 MeSH descriptor Body Fat Distribution explode all trees
- #8 MeSH descriptor Body Mass Index explode all trees
- #9 MeSH descriptor Skinfold Thickness explode all trees
- #10 MeSH descriptor Waist-Hip Ratio explode all trees
- #11 ("body weigh*" or bodyweigh* or "body mass*" or bodymass or "body fat*" or bodyfat*)
- #12 MeSH descriptor Overnutrition, this term only
- #13 (overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*)
- #14 (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13)
- #15 MeSH descriptor Child explode all trees
- #16 MeSH descriptor Adolescent, this term only

- #17 (child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or “young people” or “young person*” or pediatr* or paediatr*)
- #18 (#15 OR #16 OR #17)
- #19 MeSH descriptor Exercise, this term only
- #20 MeSH descriptor Exercise Therapy, this term only
- #21 MeSH descriptor Physical Exertion, this term only
- #22 MeSH descriptor Motor Activity, this term only
- #23 MeSH descriptor Sports, this term only
- #24 (sport*)
- #25 MeSH descriptor Physical Education and Training explode all trees
- #26 (physical near/3 (activit* or education* or exertion* or training))
- #27 (exercise*)
- #28 MeSH descriptor Diet Therapy explode all trees
- #29 ((diet or dieting) near/5 (health* or weight*))
- #30 (calorie near/3 (control or reduc* or restriction))
- #31 “food choice*”
- #32 (“fat camp*” or “weight loss camp”*)
- #33 “nutrition education”
- #34 MeSH descriptor Nutrition Therapy, this term only
- #35 MeSH descriptor Behavior Therapy, this term only
- #36 MeSH descriptor Cognitive Therapy, this term only
- #37 MeSH descriptor Psychotherapy, this term only
- #38 (behavio:r* near/3 (therap* or technique* or modif* or intervention*))
- #39 (cognit* near/3 (therap* or technique* or modif* or intervention*))
- #40 CBT
- #41 (psychotherap* or psycho-therap*)
- #42 MeSH descriptor Family Therapy, this term only
- #43 (family near/3 (therap* or intervention*))
- #44 family-based
- #45 MeSH descriptor Sedentary Lifestyle, this term only
- #46 (sedentary near/3 (lifestyle or behavio:r*))
- #47 MeSH descriptor Video Games, this term only
- #48 MeSH descriptor Television, this term only
- #49 (television or tv)
- #50 “screen time”
- #51 (psycho-social or psychosocial)
- #52 MeSH descriptor Health Promotion explode all trees
- #53 MeSH descriptor Health Education, this term only
- #54 (health* near/3 (promot* or educat* or lifestyle))
- #55 MeSH descriptor Life Style, this term only
- #56 (lifestyle* or life-style*)
- #57 ((video or computer) next game*)
- #58 (#19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56 OR #57)
- #59 (#14 AND #18 AND #58)

Ovid MEDLINE

1950 to 17 February 2012, searched 22 February 2012 [2145 records]

1946 to Week 4 April 2013, searched 7 May 2013. Limited to ED=20120217-20130507 [1009 records]

- 1 exp Overweight/
- 2 Body Weight/
- 3 (obes\$ or overweight or over-weight).tw.

4 exp Body Weight Changes/
 5 (weight adj2 (loss or lost or losing or reduc\$)).tw.
 6 (weight adj2 (gain\$ or increas\$)).tw.
 7 exp body fat distribution/ or body mass index/ or skinfold thickness/ or waist-hip ratio/
 8 (body weigh\$ or bodyweigh\$ or body mass\$ or bodymass or body fat\$ or bodyfat\$).tw.
 9 Overnutrition/
 10 (overeate\$ or over-eat\$ or overnourish\$ or over-nourish\$ or overnutrit\$ or over-nutrit\$).tw.
 11 or/1-10
 12 exp Child/
 13 Adolescent/
 14 (child\$ or schoolchild\$ or preschool\$ or pre-school\$ or schoolage\$ or school-age\$ or schoolboy\$ or schoolgirl\$ or boy\$ or girl\$
 or preteen\$ or teen\$ or adolescen\$ or youth\$ or young people or young person\$ or pediater\$ or paediatric\$).tw. (1087380)
 15 12 or 13 or 14
 16 Exercise/ or Exercise Therapy/
 17 Physical Exertion/
 18 Motor Activity/
 19 Sports/
 20 sport\$.tw.
 21 exp "Physical Education and Training"/
 22 (physical adj3 (activit\$ or education\$ or exertion\$ or training)).tw.
 23 exercise\$.tw.
 24 exp diet therapy/
 25 ((diet or dieting) adj5 (health\$ or weight\$)).tw.
 26 (calorie adj3 (control or reduc\$ or restriction)).tw.
 27 food choice\$.tw.
 28 (fat camp\$ or weight loss camp\$).tw.
 29 nutrition education.tw.
 30 Nutrition Therapy/
 31 behavior therapy/
 32 Cognitive Therapy/
 33 psychotherapy/
 34 (behavioral adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 35 (cognitive adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 36 CBT.tw.
 37 (psychotherap\$ or psycho-therap\$).tw.
 38 family therapy/
 39 (family adj3 (therap\$ or intervention\$)).tw.
 40 family-based.tw.
 41 sedentary lifestyle/
 42 (sedentary adj3 (lifestyle or behavior\$)).tw.
 43 video games/
 44 television/
 45 (television or tv).tw.
 46 "screen time".tw.
 47 (psycho-social or psychosocial).tw.
 48 exp Health Promotion/
 49 Health Education/
 50 (health\$ adj3 (promot\$ or educat\$ or lifestyle)).tw.
 51 lifestyle/
 52 (lifestyle\$ or life-style\$).tw.
 53 ((video or computer) adj game\$).tw.
 54 or/16-53
 55 11 and 15 and 54

56 randomized controlled trial.pt.
 57 controlled clinical trial.pt.
 58 randomi#ed.ab.
 59 placebo\$.ab.
 60 drug therapy.fs.
 61 randomly.ab.
 62 trial.ab.
 63 groups.ab.
 64 or/56-63
 65 exp animals/ not humans.sh.
 66 64 not 65
 67 55 and 66

EMBASE (Ovid)

1980 to Week 7 2012, searched 22 February 2012 [3887 records]

1980 to Week 18 2013, searched 7 May 2013. Limited to EM=201209-21318 [860 records]

1 exp Overweight/
 2 Body Weight/
 3 (obes\$ or overweight or over-weight).tw.
 4 exp Body Weight Changes/
 5 (weight adj2 (loss or lost or losing or reduc\$)).tw.
 6 (weight adj2 (gain\$ or increas\$)).tw.
 7 exp body fat distribution/ or body mass index/ or skinfold thickness/ or waist-hip ratio/
 8 (body weigh\$ or bodyweigh\$ or body mass\$ or bodymass or body fat\$ or bodyfat\$).tw.
 9 Overnutrition/
 10 (overeate\$ or over-eat\$ or overnourish\$ or over-nourish\$ or overnutrit\$ or over-nutrit\$).tw.
 11 or/1-10
 12 exp Child/
 13 Adolescent/
 14 (child\$ or schoolchild\$ or preschool\$ or pre-school\$ or schoolage\$ or school-age\$ or schoolboy\$ or schoolgirl\$ or boy\$ or girl\$ or preteen\$ or teen\$ or adolescens\$ or youth\$ or young people or young person\$ or pediater\$ or paediatric\$).tw.
 15 12 or 13 or 14
 16 Exercise/ or Exercise Therapy/
 17 Physical Exertion/
 18 Motor Activity/
 19 Sports/
 20 sport\$.tw.
 21 exp "Physical Education and Training"/
 22 (physical adj3 (activit\$ or education\$ or exertion\$ or training)).tw.
 23 exercise\$.tw.
 24 exp diet therapy/
 25 ((diet or dieting) adj5 (health\$ or weight\$)).tw.
 26 (calorie adj3 (control or reduc\$ or restriction)).tw.
 27 food choice\$.tw.
 28 (fat camp\$ or weight loss camp\$).tw.
 29 nutrition education.tw.
 30 Nutrition Therapy/
 31 behavior therapy/
 32 Cognitive Therapy/
 33 psychotherapy/
 34 (behavio?r\$ adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 35 (cognit\$ adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 36 CBT.tw.

37 (psychotherap\$ or psycho-therap\$).tw.
 8 family therapy/
 39 (family adj3 (therap\$ or intervention\$)).tw.
 40 family-based.tw.
 41 sedentary lifestyle/ (1338)
 42 (sedentary adj3 (lifestyle or behavior\$)).tw.
 43 video games/
 44 television/
 45 (television or tv).tw.
 46 "screen time".tw.
 47 (psycho-social or psychosocial).tw.
 48 exp Health Promotion/
 49 Health Education/
 50 (health\$ adj3 (promot\$ or educat\$ or lifestyle)).tw.
 51 lifestyle/
 52 (lifestyle\$ or life-style\$).tw.
 53 ((video or computer) adj game\$).tw.
 54 or/16-53
 55 11 and 15 and 54
 56 random\$.tw.
 57 factorial\$.tw.
 58 crossover\$.tw.
 59 cross over\$.tw.
 60 cross-over\$.tw.
 61 placebo\$.tw.
 62 (doubl\$ adj blind\$).tw.
 63 (singl\$ adj blind\$).tw.
 64 assign\$.tw.
 65 allocat\$.tw.
 66 volunteer\$.tw.
 67 Crossover Procedure/
 68 double-blind procedure.tw.
 69 Randomized Controlled Trial/
 70 Single Blind Procedure/
 71 or/56-70
 72 55 and 71

PsycINFO (Ovid)

1806 to Week 2 February 2012, searched 22 February 2012 [1460 records]

1806 to Week 4 April 2013, searched 7 May 2013, limited to UP=20120218-20130507 [311 records]

1 exp Overweight/
 2 Body Weight/
 3 (obes\$ or overweight or over-weight).tw.
 4 (weight adj2 (loss or lost or losing or reduc\$)).tw.
 5 (weight adj2 (gain\$ or increas\$)).tw.
 6 exp body fat distribution/ or body mass index/ or skinfold thickness/ or waist-hip ratio/
 7 (body weigh\$ or bodyweigh\$ or body mass\$ or bodymass or body fat\$ or bodyfat\$).tw.
 8 (overeat\$ or over-eat\$ or overnourish\$ or over-nourish\$ or overnutrit\$ or over-nutrit\$).tw.
 9 (child\$ or schoolchild\$ or preschool\$ or pre-school\$ or schoolage\$ or school-age\$ or schoolboy\$ or schoolgirl\$ or boy\$ or girl\$ or preteen\$ or teen\$ or adolescen\$ or youth\$ or young people or young person\$ or pediater\$ or paediatr\$).tw.
 10 Exercise/ or Exercise Therapy/
 11 Physical Activity/
 12 Sports/

13 sport\$.tw.
 14 exp Physical Education/
 15 (physical adj3 (activit\$ or education\$ or exertion\$ or training)).tw.
 16 exercise\$.tw.
 17 ((diet or dieting) adj5 (health\$ or weight\$)).tw.
 18 (calorie adj3 (control or reduc\$ or restriction)).tw.
 19 food choice\$.tw.
 20 (fat camp\$ or weight loss camp\$).tw.
 21 nutrition education.tw.
 22 behavior therapy/
 23 Cognitive Therapy/
 24 psychotherapy/
 25 (behavio?r\$ adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 26 (cognit\$ adj3 (therap\$ or technique\$ or modif\$ or intervention\$)).tw.
 27 CBT.tw.
 28 (psychotherap\$ or psycho-therap\$).tw.
 29 family therapy/
 30 (family adj3 (therap\$ or intervention\$)).tw.
 31 family-based.tw.
 32 sedentary lifestyle/
 33 (sedentary adj3 (lifestyle or behavio?r\$)).tw.
 34 video games/
 35 television/
 36 (television or tv).tw.
 37 "screen time".tw.
 38 (psycho-social or psychosocial).tw.
 39 exp Health Promotion/
 40 Health Education/
 41 (health\$ adj3 (promot\$ or educat\$ or lifestyle)).tw.
 42 lifestyle/
 43 (lifestyle\$ or life-style\$).tw.
 44 ((video or computer) adj game\$).tw.
 45 or/1-8
 46 or/10-44
 47 9 and 45 and 46
 48 Treatment Effectiveness Evaluation/
 49 exp Treatment Outcomes/
 50 Psychotherapeutic Outcomes/
 51 PLACEBO/
 52 exp Followup Studies/
 53 placebo\$.tw.
 54 random\$.tw.
 55 comparative stud\$.tw.
 56 randomi#ed controlled trial\$.tw.
 57 (clinical adj3 trial\$).tw.
 58 (research adj3 design).tw.
 59 (evaluat\$ adj3 stud\$).tw.
 60 (prospectiv\$ adj3 stud\$).tw.
 61 ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj3 (blind\$ or mask\$)).tw.
 62 control\$.tw.
 63 62 or 54 or 52 or 60 or 59 or 55 or 48 or 53 or 49 or 61 or 57 or 51 or 50 or 58 or 56
 64 47 and 63

CINAHL Plus (EBSCO host)

1937 to current, searched 22 February 2012 [1933 records]

1937 to current, searched 7 May 2013, limited to EM=20120222- [484 records]

S47 (S44 or S45) and (S43 and S46)

S46 S44 or S45

S45 (MH "Randomized Controlled Trials")

S44 ((random* or blind* or allocat* or assign* or trial* or placebo* or crossover* or cross-over*))

S43 S9 and S10 and S42

S42 (S11 or S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 or S34 or S35 or S36 or S37 or S38 or S39 or S40 or S41)

S41 (((video or computer) N1 game*))

S40 ((lifestyle* or life-style*))

S39 ((health* N3 (promot* or educat* or lifestyle)))

S38 ((psycho-social or psychosocial))

S37 ("screen time")

S36 ((television or tv))

S35 ((sedentary N3 (lifestyle or behavior?r*)))

S34 (family-based)

S33 ((family N3 (therap* or intervention*)))

S32 ((psychotherap* or psycho-therap*))

S31 CBT

S30 ((cognit* N3 (therap* or technique* or modif* or intervention*)))

S29 ((behavior#r* N3 (therap* or technique* or modif* or intervention*)))

S28 ("nutrition education")

S27 (("fat camp*" or "weight loss camp*"))

S26 ("food choice*")

S25 ((calorie N3 (control or reduc* or restriction)))

S24 (((diet or dieting) N5 (health* or weight*)))

S23 (exercise*)

S22 ((physical N3 (activit* or education* or exertion* or training)))

S21 (sport*)

S20 (MH "Health Education")

S19 (MH "Health Promotion")

S18 (MH "Life Style")

S17 (MH "Television")

S16 (MH "Video Games")

S15 (MH "Family Therapy")

S14 (MH "Cognitive Therapy")

S13 (MH "Diet Therapy") OR (MH "Behavior Therapy")

S12 (MH "Sports")

S11 (MH "Exercise") OR (MH "Physical Fitness")

S10 ((child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or young people or young person* or pediater* or paediatr*))

S9 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8

S8 ((overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*))

S7 (("body weigh*" or bodyweigh* or body mass* or bodymass or "body fat*" or bodyfat*))

S6 ((weight N2 (gain* or increas*)))

S5 ((weight N2 (loss or lost or losing or reduc*)))
S4 (MH "Hyperphagia")
S3 (MH "Weight Loss")
S2 (MH "Obesity")
S1 ((obes* or overweight or over-weight))

IBSS (International Bibliography of Social Studies) (Proquest)

1951 to current, searched 22 February 2012 [459 records]

1951 to current, searched 8 May 2013, limited to publication year 2012 to 2013 [113 records]

S1 ((obes* or overweight or over-weight))
S2 ((weight near/2 (loss or lost or losing or reduc*)))
S3 ((weight near/2 (gain* or increas*)))
S4 (("body weigh*" or bodyweigh* or body mass* or bodymass or "body fat*" or bodyfat*))
S5 ((overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*))
S6 s1 or s2 or s3 or s4 or s5
S7 ((child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or young people or young person* or pediater* or paediatric*))
S8 (sport*)
S9 ((physical near/3 (activit* or education* or exertion* or training)))
S10 (exercise*)
S11 (((diet or dieting) near/5 (health* or weight*)))
S12 ((calorie near/3 (control or reduc* or restriction)))
S13 ("food choice*")
S14 ("fat camp*" or "weight loss camp*")
S15 ("nutrition education")
S16 ((behavio?r* near/3 (therap* or technique* or modif* or intervention*)))
S17 ((cognit* near/3 (therap* or technique* or modif* or intervention*)))
S18 (CBT)
S19 ((psychotherap* or psycho-therap*))
S20 ((family near/3 (therap* or intervention*)))
S21 (family-based)
S22 ((sedentary near/3 (lifestyle or behavio?r*)))
S23 ((television or tv))
S24 ("screen time")
S25 ((psycho-social or psychosocial))
S26 ((health* near/3 (promot* or educat* or lifestyle)))
S27 ((lifestyle* or life-style*))
S28 (((video or computer) near/1 game*))
S29 s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16 or s17 or s18 or s19 or s20
S30 s21 or s22 or s23 or s24 or s25 or s26 or s27 or s28
S31 s29 or s30
S32 s6 and s7 and s31

ERIC (Proquest)

1966 to current searched 22 February 2012 [1363 records]

1966 to current searched 8 May 2013, limited to publication year 2012 to 2013 [205 records]

S1 ((obes* or overweight or over-weight))
S2 ((weight near/2 (loss or lost or losing or reduc*)))
S3 ((weight near/2 (gain* or increas*)))
S4 (("body weigh*" or bodyweigh* or body mass* or bodymass or "body fat*" or bodyfat*))
S5 ((overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*))
S6 s1 or s2 or s3 or s4 or s5

S7 ((child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or young people or young person* or pediater* or paediatr*))
 S8 (sport*)
 S9 ((physical near/3 (activit* or education* or exertion* or training)))
 S10 (exercise*)
 S11 (((diet or dieting) near/5 (health* or weight*)))
 S12 ((calorie near/3 (control or reduc* or restriction)))
 S13 ("food choice*")
 S14 (("fat camp*" or "weight loss camp*"))
 S15 ("nutrition education")
 S16 ((behavio?r* near/3 (therap* or technique* or modif* or intervention*)))
 S17 ((cognit* near/3 (therap* or technique* or modif* or intervention*)))
 S18 (CBT)
 S19 ((psychotherap* or psycho-therap*))
 S20 ((family near/3 (therap* or intervention*)))
 S21 (family-based)
 S22 ((sedentary near/3 (lifestyle or behavio?r*)))
 S23 ((television or tv))
 S24 ("screen time")
 S25 ((psycho-social or psychosocial))
 S26 ((health* near/3 (promot* or educat* or lifestyle)))
 S27 ((lifestyle* or life-style*))
 S28 (((video or computer) near/1 game*))
 S29 s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16 or s17 or s18 or s19 or s20
 S30 s21 or s22 or s23 or s24 or s25 or s26 or s27 or s28
 S31 s29 or s30
 S32 s6 and s7 and s31

Conference Proceeding Citation Index-Science and Conference Proceeding Citation Index-Social Sciences & Humanities (ISI Web of Knowledge)

1990 to 17 February 2012, searched 22 February 2012 [871 records]

1990 to 3 May 2013, searched 8 May 2013 [12 records]

#32 #31 AND #30

#31 Topic=((random* or blind* or allocat* or assign* or trial* or placebo* or crossover* or cross-over*))

#30 #29 AND #7

#29 #28 OR #27 OR #26 OR #25 OR #24 OR #23 OR #22 OR #21 OR #20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 OR #13 OR #12 OR #11 OR #10 OR #9 OR #8

#28 Topic=((video or computer) near/1 game*))

#27 Topic=((lifestyle* or life-style*))

#26 Topic=((health* near/3 (promot* or educat* or lifestyle)))

#25 Topic=((psycho-social or psychosocial))

#24 Topic=("screen time")

#23 Topic=((television or tv))

#22 Topic=((sedentary near/3 (lifestyle or behavio?r*)))

#21 Topic=(family-based)

#20 Topic=((family near/3 (therap* or intervention*)))

#19 Topic=((psychotherap* or psycho-therap*))

#18 Topic=(CBT)

#17 Topic=((cognit* near/3 (therap* or technique* or modif* or intervention*)))

#16 Topic=((behavio?r* near/3 (therap* or technique* or modif* or intervention*)))

#15 Topic=("nutrition education")

#14 Topic(("fat camp*" or "weight loss camp*"))

#13 Topic=("food choice*")

#12 Topic=((calorie near/3 (control or reduc* or restriction)))

#11 Topic=((diet or dieting) near/5 (health* or weight*))
 #10 Topic=(exercise*)
 #9 Topic=((physical near/3 (activit* or education* or exertion* or training)))
 #8 Topic=(sport*)
 #7 Topic=((child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or young people or young person* or pediater* or paediatric*))
 #6 #5 OR #4 OR #3 OR #2 OR #1
 #5 Topic=((overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*))
 #4 Topic=(("body weigh*" or bodyweight* or body mass* or bodymass or "body fat*" or bodyfat*))
 #3 Topic=((weight near/2 (gain* or increas*))
 #2 Topic=((weight near/2 (loss or lost or losing or reduc*))
 #1 Topic=((obes* or overweight or over-weight))

Cochrane Database of Systematic Reviews

2012 (Issue 12), searched 15 January 2012 [22 records]

2013 (Issue 4), searched 8 May 2013, limited to publication year 2012 to 2013 [11 records]

#1MeSH descriptor: [Overweight] explode all trees
 #2MeSH descriptor: [Body Weight] this term only
 #3(obese or obesity or overweight or over-weight):ti,ab
 #4MeSH descriptor: [Body Weight Changes] explode all trees
 #5(weight near/2 (loss or lost or losing or reduc*)):ti,ab
 #6(weight near/2 (gain* or increas*)):ti,ab
 #7MeSH descriptor: [Body Fat Distribution] explode all trees
 #8MeSH descriptor: [Body Mass Index] explode all trees
 #9MeSH descriptor: [Skinfold Thickness] explode all trees
 #10MeSH descriptor: [Waist-Hip Ratio] explode all trees
 #11("body weigh*" or bodyweight* or "body mass*" or bodymass or "body fat*" or bodyfat*):ti,ab
 #12MeSH descriptor: [Overnutrition] this term only
 #13(overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*):ti,ab
 #14#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 #11 or #12 or #13
 #15MeSH descriptor: [Child] explode all trees
 #16MeSH descriptor: [Adolescent] this term only
 #17(child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or "young people" or "young person*" or pediater* or paediatric*):ti,ab
 #18#15 or #16 or #17
 #19#14 and #18
 #20MeSH descriptor: [Exercise] this term only
 #21MeSH descriptor: [Exercise Therapy] this term only
 #22MeSH descriptor: [Physical Exertion] this term only
 #23MeSH descriptor: [Motor Activity] this term only
 #24MeSH descriptor: [Sports] this term only
 #25(sport*):ti,ab
 #26MeSH descriptor: [Physical Education and Training] explode all trees
 #27(physical near/3 (activit* or education* or exertion* or training)):ti,ab
 #28(exercise*):ti,ab
 #29MeSH descriptor: [Diet Therapy] explode all trees
 #30((diet or dieting) near/5 (health* or weight*)):ti,ab
 #31(calorie near/3 (control or reduc* or restriction)):ti,ab
 #32("food choice*"):ti,ab
 #33("fat camp*" or "weight loss camp*"):ti,ab
 #34("nutrition education") ti,ab
 #35MeSH descriptor: [Nutrition Therapy] this term only
 #36MeSH descriptor: [Behavior Therapy] this term only
 #37MeSH descriptor: [Cognitive Therapy] this term only

#38MeSH descriptor: [Psychotherapy] this term only
 #39((behavior* or behavior*) near/3 (therap* or technique* or modif* or intervention*)):ti,ab
 #40(cognit* near/3 (therap* or technique* or modif* or intervention*)):ti,ab
 #41(CBT) ti,ab
 #42(psychotherap* or psycho-therap*) ti,ab
 #43MeSH descriptor: [Family Therapy] this term only
 #44(family near/3 (therap* or intervention*)):ti,ab
 #45(family-based):ti,ab
 #46MeSH descriptor: [Sedentary Lifestyle] this term only
 #47(sedentary near/3 (lifestyle or behavio*r*)):ti,ab
 #48MeSH descriptor: [Video Games] this term only
 #49MeSH descriptor: [Television] this term only
 #50(television or tv):ti,ab
 #51(“screen time”):ti,ab
 #52(psycho-social or psychosocial):ti,ab
 #53MeSH descriptor: [Health Promotion] explode all trees
 #54MeSH descriptor: [Health Education] this term only
 #55(health* near/3 (promot* or educat* or lifestyle)):ti,ab
 #56MeSH descriptor: [Life Style] this term only
 #57(lifestyle* or life-style*):ti,ab
 #58((video or computer) next game*):ti,ab
 #59#20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58
 #60#19 and #59

Database of Abstracts of Reviews of Effects (DARE)

2012 (4), searched 15 January 2013 [eight records]

2013 (2), searched 8 May 2013, limited to publication year 2012 to 2013 [16 records]

#1MeSH descriptor: [Overweight] explode all trees
 #2MeSH descriptor: [Body Weight] this term only
 #3(obese or obesity or overweight or over-weight):ti,ab
 #4MeSH descriptor: [Body Weight Changes] explode all trees
 #5(weight near/2 (loss or lost or losing or reduc*)):ti,ab
 #6(weight near/2 (gain* or increas*)):ti,ab
 #7MeSH descriptor: [Body Fat Distribution] explode all trees
 #8MeSH descriptor: [Body Mass Index] explode all trees
 #9MeSH descriptor: [Skinfold Thickness] explode all trees
 #10MeSH descriptor: [Waist-Hip Ratio] explode all trees
 #11(“body weigh*” or bodyweigh* or “body mass*” or bodymass or “body fat*” or bodyfat*):ti,ab
 #12MeSH descriptor: [Overnutrition] this term only
 #13(overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*):ti,ab
 #14#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 #11 or #12 or #13
 #15MeSH descriptor: [Child] explode all trees
 #16MeSH descriptor: [Adolescent] this term only
 #17(child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescen* or youth* or “young people” or “young person*” or pediater* or paediatr*):ti,ab
 #18#15 or #16 or #17
 #19#14 and #18
 #20MeSH descriptor: [Exercise] this term only
 #21MeSH descriptor: [Exercise Therapy] this term only
 #22MeSH descriptor: [Physical Exertion] this term only
 #23MeSH descriptor: [Motor Activity] this term only
 #24MeSH descriptor: [Sports] this term only

#25(sport*):ti,ab
 #26MeSH descriptor: [Physical Education and Training] explode all trees
 #27(physical near/3 (activit* or education* or exertion* or training)):ti,ab
 #28(exercise*):ti,ab
 #29MeSH descriptor: [Diet Therapy] explode all trees
 #30((diet or dieting) near/5 (health* or weight*)):ti,ab
 #31(calorie near/3 (control or reduc* or restriction)):ti,ab
 #32("food choice*"):ti,ab
 #33("fat camp*" or "weight loss camp*"):ti,ab
 #34("nutrition education") ti,ab
 #35MeSH descriptor: [Nutrition Therapy] this term only
 #36MeSH descriptor: [Behavior Therapy] this term only
 #37MeSH descriptor: [Cognitive Therapy] this term only
 #38MeSH descriptor: [Psychotherapy] this term only
 #39((behavior* or behavior*) near/3 (therap* or technique* or modif* or intervention*)):ti,ab
 #40(cognit* near/3 (therap* or technique* or modif* or intervention*)):ti,ab
 #41(CBT) ti,ab
 #42(psychotherap* or psycho-therap*) ti,ab
 #43MeSH descriptor: [Family Therapy] this term only
 #44(family near/3 (therap* or intervention*)):ti,ab
 #45(family-based):ti,ab
 #46MeSH descriptor: [Sedentary Lifestyle] this term only
 #47(sedentary near/3 (lifestyle or behavio*r*)):ti,ab
 #48MeSH descriptor: [Video Games] this term only
 #49MeSH descriptor: [Television] this term only
 #50(television or tv):ti,ab
 #51("screen time"):ti,ab
 #52(psycho-social or psychosocial):ti,ab
 #53MeSH descriptor: [Health Promotion] explode all trees
 #54MeSH descriptor: [Health Education] this term only
 #55(health* near/3 (promot* or educat* or lifestyle)):ti,ab
 #56MeSH descriptor: [Life Style] this term only
 #57(lifestyle* or life-style*):ti,ab
 #58((video or computer) next game*):ti,ab
 #59#20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58
 #60#19 and #59

SPORTDiscus (EBSCO)

Searched from 1980 to current on 05 March 2012 and 06 May 2013

S66 (S63 and S65)

S65 S17 and S57 and S64

S64 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13

S63 S61 NOT S62

S62 SU animals NOT SU humans

S61 (S58 or S59 or S60)

S60 AB (random* or blind* or allocat* or assign* or trial* or placebo* or crossover or cross-over)

S59 SU controlled clinical trial

S58 SU randomized controlled trials

S57 (S19 or S20 or S21 or S22 or S23 or S24 or S25 or S26 or S27 or S28 or S29 or S30 or S31 or S32 or S33 or S34 or S35 or S36 or S37 or S38 or S39 or S40 or S41 or S42 or S43 or S44 or S45 or S46 or S47 or S48 or S49 or S50 or S51 or S52 or S53 or S54 or S55 or S56)

S56 TX ((computer or video or internet) N1 game)

S55 SU computer game
 S54 TX lifestyle* or life-style*
 S53 TX (health* N3 (lifestyle or promotion or education or behavior))
 S52 SU lifestyle
 S51 SU Health Education or SU Health Promotion
 S50 TX psycho-social or psychosocial
 S49 TX "screen time"
 S48 TX television or TV
 S47 SU video games
 S46 SU television
 S45 TX (Sedentary N3 (behavior or lifestyle))
 S44 SU Sedentary
 S43 TX family-based
 S42 TX (family N3 (therapy* or intervention*))
 S41 SU family therapy
 S40 TX psychotherapy* or psycho-therapy* Rerun View Details Edit Interface -
 S39 TX (behavior N3 (therapy* or technique* or modification* or intervention*))
 S38 TX CBT
 S37 SU Cognitive therapy
 S36 SU Behavior therapy
 S35 SU Psychotherapy
 S34 TX "food choice"
 S33 TX (calorie N3 (control or reduction* or restriction))
 S32 TX ((diet or dieting) N5 (health* or weight*))
 S31 TX "fat camp*" or "weight loss camp*"
 S30 SU food habit
 S29 SU nutrition therapy
 S28 SU diet therapy
 S27 TX exercise*
 S26 TX sport*
 S25 TX (Physical N2 (activity* or education* or training or fitness))
 S24 SU Physical training
 S23 SU Physical activity
 S22 SU Physical education
 S21 SU Sport
 S20 SU Exercise Therapy
 S19 SU Exercise
 S18 (S14 or S15 or S16 or S17)
 S17 TX child* or schoolchild* or preschool* or pre-school* or schoolage* or school-age* or schoolboy* or schoolgirl* or boy* or girl* or preteen* or teen* or adolescent* or youth* or young people or young person* or pediatric* or paediatric*
 S16 SU teenager
 S15 SU adolescent
 S14 SU child
 S13 TX Overeat* or over-eat* or overnourish* or over-nourish* or overnutrit* or over-nutrit*
 S12 TX "waist-hip ratio"
 S11 TX "body weight*" or bodyweigh* or body mass* or bodymass or "body fat*" or bodyfat*
 S10 TX waist-hip ration
 S9 TX skin fold thickness
 S8 TX body fat distribution
 S7 SU body composition
 S6 TX (weight N2 (gain* or increase*))
 S5 TX (weight N2 (loss or lost or losing or reduction*))
 S4 TX obese* or overweight or over-weight

S3 SU body weight change

S2 SU body weight

S1 SU overweight

MIT Cognet searched 23 February 2012 and 06 May 2013

(child* OR adolesc*) AND (obes* OR overweight)

Database on Obesity and Sedentary Behaviour Studies searched 23 February 2012 and 06 May 2013

Child* OR adolesc* OR youth OR boy* Or girl* Or paediatr* OR pediater*

Database of Promoting Health Effectiveness Reviews (DoPHER) searched 23 February 2012 and 06 May 2013

(Child* OR adolesc* OR youth OR boy* OR girl* OR paediatr* OR pediater*) AND (obes* OR overweight OR BMI OR "body mass index" OR "body weight change")

Trials Register of Promoting Health Interventions (TRoPHI) searched 23 February 2012 and 06 May 2013

(child* OR adolesc* OR youth OR boy* OR girl* OR paediatr* OR pediater*) AND (obes* OR overweight)

Bibliomap searched 23 February 2012 and 06 May 2013

(child* OR adolesc* OR youth OR boy* OR girl* OR paediatr* OR pediater*) AND (obes* OR overweight)

www.controlled-trials.com searched 23 February 2012 and 06 May 2013

Obes* child*

Obes* youth

Obes* adolesc*

Overweight child*

www.who.int/trialsearch searched 27 February 2012 and 06 May 2013

Condition: (obes% or overweight) restricted to "Search for clinical trials in children" option

OpenSIGLE (opengray) searched 23 February 2012 and 06 May 2013

(child* OR adolesc* OR youth or boy* or girl*) AND (obes* OR overweight)

Networked Digital Library of Theses and Dissertations searched 28 February 2012 and 06 May 2013

(children OR adolescents OR youth) and (overweight OR obesity) AND (randomised controlled trial)

Appendix 2. Summary of school achievement and cognitive function measures and test tools used in included studies

Outcomes	Tests	Cognitive processes	Standardised score/scale range	Units	Scale direction
SCHOOL ACHIEVEMENT					
Mathematics	CAT-3 W-J Tests of Achievement III (broad math)	Number concepts, measurement, patterns, data analysis and probability, geometry and spatial sense Simple and complex calculation skills, math fluency (number facility), mathematical reasoning and problem analysis and solving	M = 500, SD = 70 M = 100, SD = 15 (range zero to 200) ≥ 131 = very superior; 121 to 130 = superior; 111 to 120 = high average; 90 to 110 = average;	Number of correct answers Number of correct responses	High = better performance High = better performance

(Continued)

				80 to 89 = low average; 70 to 79 = low; ≤ 69 = very low		
Language	CAT-3	Sentence structure, writing conventions, paragraph structure, information management	M = 500, SD = 70	Number of correct responses	High = better performance	
Reading	CAT-3 W-J Tests of Achievement III (broad reading)	Reading decoding (letter-word identification), words/phrases in context, reading comprehension (stated information, visual materials, central thought), analysis of text, critical assessment Reading decoding (letter-word identification), reading fluency (speed), reading comprehension of textual information	M = 500, SD = 70 M = 100, SD = 15 (range zero to 200) ≥ 131 = very superior; 121 to 130 = superior; 111 to 120 = high average; 90 to 110 = average; 80 to 89 = low average; 70 to 79 = low; ≤ 69 = very low	Number of correct responses Number of correct responses	High = better performance High = better performance	
Vocabulary	PPVT III	Receptive vocabulary acquisition	M = 100, SD = 15	Number of correct responses	High = better performance	
COGNITIVE FUNCTION						
Carroll (1993)	Authors of studies	Classification of cognitive domains is challenging because most tests measure abilities in more than one cognitive domain, and therefore overlapping occurs. We chose this classification for two reasons: (1) We referred to what the authors said they would test, and (2) the modified classification by Carroll 1993 was used by another Cochrane Review (Gogia 2012)				
Gf	Executive function	D-KEFS (Design Fluency and Trail-Making) CAS (Planning Scale)	Sub-scales measure visual-spatial skills, response inhibition, motor planning, visual scanning, speed and cognitive flexibility M = 10, SD = 3 M = 100, SD = 15	Number of correct responses Sum of total time scale score and accuracy scale score (ratio of number)	High = better performance High = better performance	

(Continued)

			ity Strategy generation and application, self regulation, intentionality and utilisation of knowledge		of correct responses and total time)	
	Inhibitory control	KiTAP (Go/No Go Task)	Impulsivity	M = 50, SD = 10	Reaction time and number of errors	Low = better performance
	Working memory	CAS (successive processing)	Remembering or completing information in a specific order or sequence	M = 100, SD = 15	Sum of number of correct responses scale score and total time scale score	High = better performance
	Simultaneous processing ^a	CAS	Non-verbal and verbal processing, analyses and synthesis of logical and grammatical components of language and comprehension of word relationships, nonverbal matrices, verbal spatial relations and figure memory	M = 100, SD = 15	Scale score of number of correct responses	High = better performance
Speed and processing	Attention	CAS ^b KiTAP	Expressive attention, number detection and receptive attention Sustained attention	M = 100, SD = 15 M = 50, SD = 10 (range zero to 100)	Sum of scale scores of accuracy one and accuracy two; accuracy one (ratio of number of correct	High = better performance High = better performance

(Continued)

			including aspects of working memory and mental flexibility		responses and total time); accuracy two (ratio of [number of correct responses minus number of false detections] and total time) Number of correct responses based on the difference in maximal numbers of possible errors and omissions	
--	--	--	--	--	--	--

CAT-3: Canadian Achievement Test, version 3; W-J: Woodcock-Johnson; PPVT III: Peabody Picture Vocabulary Test, version 3; CAS: Das-Naglieri-Cognitive Assessment System; KiTAP: [Kinderversion der Testbatterie zur Aufmerksamkeitsprüfung] Attention test battery for children; D-KEFS: Delis-Kaplan Executive Function System. ^aSimultaneous processing includes tests of memory and executive function. ^bCAS also includes measures that could be categorised as speed or executive function.

CONTRIBUTIONS OF AUTHORS

All review authors contributed to the development of this protocol. AM and DHS drafted the protocol, with significant input from SDS and JS. AM, DHS and SDS developed the search strategy. AM and DHS screened the titles and abstracts of potentially eligible studies and reports and assessed the full report of potentially relevant studies for eligibility, in consensus with SDS and JS when necessary. AM drafted the full review with regular input from all review authors.

DECLARATIONS OF INTEREST

- Anne Martin - none known.
- David H Saunders - none known.
- Susan D Shenkin - none known.
- John Sproule - none known.

SOURCES OF SUPPORT

Internal sources

- The University of Edinburgh, UK.

The University of Edinburgh provided support in the form of salaries for DHS, SDS and JS; support in the form of a PhD scholarship for AM; and support for attendance at the UK Cochrane Training Courses by AM via staff development funds

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We intended from the outset to select studies based on inclusion criteria; however, we did not state this explicitly in the protocol. The intervention criterion for inclusion was that the study aimed to prevent or treat childhood obesity as a primary or secondary outcome through lifestyle interventions. The outcome criterion for inclusion was that studies measured school achievement, cognitive function and future success as defined in [Types of outcome measures](#).

We stated in the protocol that studies that included some overweight children would be included in the review only when outcomes for overweight or obese children were reported separately. Only a few studies investigated the effects of lifestyle interventions on school achievement and/or cognitive function in an overweight paediatric population; therefore we did not exclude those studies if results for this population group were not reported separately. We put all efforts in place and contacted the authors of those studies to obtain data for the overweight and/or obese subgroup.

In the protocol, we stated that we would include controlled trials. We intended to include controlled clinical trials as defined by the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011](#)); we did not intend to include non-randomised controlled trials.

For continuous outcomes measured on different scales and reported as both change data and postintervention data, we analysed the treatment effect by calculating the mean difference. We did not explicitly state this possibility in the protocol.

We provided effect sizes for studies that were inappropriate for inclusion in a meta-analysis. The protocol stated that we would provide a narrative description of study results derived from those studies.