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Identifying effective behavioural models and behaviour change strategies underpinning preschool- and school-based obesity prevention interventions aimed at 4–6-year-olds: a systematic review

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Summary

The aim of this comprehensive systematic review was to identify the most effective behavioural models and behaviour change strategies, underpinning preschool- and school-based interventions aimed at preventing obesity in 4–6-year-olds. Searching was conducted from April 1995 to April 2010 using MEDLINE, EMBASE, CINAHL, PsycINFO and The Cochrane Library. Epidemiological studies relevant to the research question with controlled assignment of participants were included in the review, if they had follow-up periods of 6 months or longer. Outcomes included markers of weight gain; markers of body composition; physical activity behaviour changes and dietary behaviour changes. Twelve studies were included in the review. The most commonly used model was social cognitive theory (SCT)/social learning theory (SLT) either as a single model or in combination with other behavioural models. Studies that used SCT/SLT in the development of the intervention had significant favourable changes in one, or more, outcome measures. In addition, interventions that (i) combined high levels of parental involvement and interactive school-based learning; (ii) targeted physical activity and dietary change; and (iii) included long-term follow-up, appeared most effective. It is suggested that interventions should also be focused on developing children's (and parents') perceived competence at making dietary and physical changes.

Keywords: Behavioural model, children, obesity prevention, (pre)-school-based intervention.

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Introduction

The Foresight report (1) and the World Health Organisation (2) have indicated that a whole system approach to tackling obesity is critical, and have stressed the importance of considering behavioural approaches alongside environmental, policy and community approaches.

The European Union-funded ToyBox study aimed to develop and test a new intervention programme that aimed to influence dietary and physical activity (PA) behaviours of children aged 4–6 to prevent obesity. A number of reviews focusing on various approaches that may be considered as part of the 'whole systems approach' to tackling childhood obesity, and also pilot work to explain why young children eat the foods they eat and why they do, or do not, participate in physical activities, were conducted to inform the development of the intervention. One of the reviews that was conducted and contributed to the evidence base of the ToyBox intervention is reported in this paper.

The importance of considering behavioural models and strategies, and the most appropriate theoretical underpinnings of behavioural change, when developing interventions to prevent childhood obesity has been highlighted by Summerbell and colleagues (3,4). Behavioural models and conceptual frameworks that have been used in childhood obesity prevention research include the tran-stheoretical model, theory of planned behaviour, health belief model (HBM), social cognitive theory (SCT) and socioecological models (5,6). However, because the developmental immaturity of young children, aged 4–6 years old, attenuates the power of socio-cognitive theories in explaining their behaviours, it is important to carefully select the theoretical background and define the most appropriate models and strategies to address young children's unstructured ways of behaving as well as their social and physical environment. Models that rely on individual decision-making processes are not appropriate to target behaviour change in younger children; the influences of family and school environments are central to their development of dietary and PA behaviours (7).

Therefore, the main aim of this comprehensive systematic review was to identify the most effective behavioural models and strategies underpinning preschool- and school-based interventions for preventing obesity in 4–6-year-olds, to be used to provide the theoretical framework of the ToyBox intervention.

Methods

Inclusion criteria

Primary studies (from 1995 onwards) that included obesity prevention interventions in children aged 4, 5 and 6 years old were incorporated into the review. Studies relevant to the research question with controlled assignment of participants were included in the review, including:

- Randomized control trials (RCTs)
- Non-RCTs
- Random allocation
- Double-blind and single-blind method
- Intervention and evaluation studies
- Matched population studies

Potentially relevant *systematic reviews* (from 1995 onwards) were also examined for studies that fitted the pre-set inclusion criteria.

Criteria for primary study inclusion in the review were:

1. Study investigates at least one of the following exposures (patterns of diet; foods and drinks; food preparation i.e. cooking methods; dietary constituents; PA and inactivity; energy intake; energy density of diet; energy expenditure);

2. Study reports at least one of the following outcomes (markers of weight gain; overweight; obesity; markers of body composition [body mass index (BMI), other weight adjusted for height measures, weight, skinfold measurements, other measures such as dual energy X-ray absorptiometry (DEXA), bio-impedance, change in body composition]; markers of distribution of fat [waist circumference, hip circumference, waist to hip ratio, skinfolds ratio, other measures such as computed tomography (CT), ultrasound]);

3. Study must have both 'before and after' measures in the same children;

4. Study participants were children aged between 4–6.9 years old (*studies including children beyond 6.9 years at baseline were excluded from this review)*;

5. Study follow-up period must be at least 6 months;

6. Study setting is preschool- and school-based.

Note that he inclusion or exclusion of a study for this review was not made on the basis of whether the authors of that study reported that their intervention was, or was not, underpinned by a behavioural theory.

Search methods

Searching was conducted in April 2010, with relevant literature included in the review up to and including the search date. The overall aim of the data synthesis was to collate and summarize the results of the studies included in the review. Although meta-analyses were intended where sufficient data existed, any meta-analytic comparisons from the included studies were impossible to run because of insufficient data (i.e. the availability of adequate information in an appropriate format and at identical points in time). Therefore, only narrative approaches to data analysis were employed in this review.

Databases

The following databases were searched as part of the searching process: MEDLINE, EMBASE, CINAHL, PsycINFO and Cochrane library incorporating DARE database, Systematic review database and HTA database.

Search strategy

A systematic search of the literature was conducted to identify relevant primary studies. Only primary studies reported from 1995 were searched for, because evidence from another review (3) suggests that trials that aim to prevent obesity in young children under 8 years of age that would meet the inclusion criteria for this review were not conducted before 1995. This was probably due to the fact that the prevalence of obesity in this age group had not started to rise significantly before this point in time. A systematic search of the literature was also conducted to identify relevant systematic reviews; as with primary

Table 1 Summary of the literature search

Database	Hits from search
Medline	7,373
Embase	6,899
Cinahl	976
Cochrane library	1,066
PsycINFO	1,110
Total (combined and de-duplicated)	11,276

studies, only recent reviews of potential relevance were considered, from 1995 onwards. Relevant primary studies and reviews published in English and German were included. The search strategy itself was designed by combining relevant search terms; the search strategy being adapted for each database where appropriate. There is an enormous amount of literature around the subject areas studied, and the search strategy was refined a number of times in order to optimize the selectivity of the search while maintaining sensitivity. The full list of search terms for this review can be found in Table 1.

The search hits were downloaded and entered into endnote reference management software, combined and duplicates were removed. These searches resulted in the identification of 11,276 papers (Table 2).

The papers identified from the searches (in Endnote) were initially screened – on the basis of titles and abstracts – by three reviewers (WD, CN, HM) to remove any papers that were clearly not relevant. Hand searching of systematic reviews and key reviews was also undertaken, 73 of which were identified and screened for further papers. This process itself produced 63 papers of potential interest. From the remaining list, 210 papers were identified as being 'potentially relevant for the review', of which 187 were original papers and 23 additional systematic reviews. From these reviews, a further eight papers were identified, resulting in 195 being put forward for possible inclusion (Fig. 1). Full text versions of all of these papers were obtained. Inclusion or exclusion of papers into the review was carried out in duplicate (WD, HM, CN) and any disagreements resolved by a fourth reviewer (CS).

Twenty-three papers remained after the duplicated full text review stage, with all papers included for data extraction. A number of these papers were publications based on the same study, which meant a total of 12 individual studies formed part of this review. Each of the studies included in the review could be comprised of single or multiple papers. One reference for each study was awarded the status of the 'primary reference'. We have ensured simple identification of each study by allocating a numbered reference to these primary references for each study (e.g. [8] refers to Manios *et al*. 2002).

Quality assessment

The Effective Public Health Practice Project Quality Assessment Tool for Quantitative Studies (9) was implemented for the studies included, examining the following criteria: (i) selection bias; (ii) study design; (iii) confounders; (iv) blinding; (v) data collection methods; (vi) analyses; and (vii) withdrawals and dropouts. Each study was assessed independently by two reviewers using the aforementioned criteria. Independent reviews were assessed for any discrepancies between component ratings and disagreements were resolved through discussion regarding differences in interpretation, before a final decision was made and agreed by both reviewers. Each of the criteria ratings were summarized as Strong; Moderate; Weak according to the assessment technique set out in the aforementioned tool, and based on this criteria each study was rated as either (i) Strong (where there were no weak ratings); (ii) Moderate (where there was one weak rating); and (iii) Weak (where there were two or more weak ratings). As such, the studies included in this review were rated as Strong quality ($n = 4$) (8,10–12), Moderate quality ($n = 5$) (13–17) and Weak quality ($n = 3$) (18–20). Quality assessment ratings for each study are included in Table 3.

The aforementioned quality assessment tool was modified in the assessment of quality scores associated with interventions reported in each study. In addition to the existing criteria to assess intervention integrity, studies were also assessed according to (i) reporting of theoretical/behavioural model(s) underpinning the intervention; (ii) specification of intervention adequate for replication; and (iii) reporting process evaluation of intervention programme. Based on combined scores for all criteria, studies were rated as having moderate quality ($n = 4$) (14,16,17,20) and high quality ($n = 8$) (8,10–13,15,18,19).

Results

Study description

Nine studies were included in this review (8,10,12,14–18,20), and although full data were unavailable for three further studies (11,13,19) they were deemed important and relevant to the objectives of this review and were therefore also reported here pending further analysis. As such, this review included all 12 studies in this and subsequent sections. Three studies were non-RCT (8,14,17), nine studies were RCTs, of which five were reported as a cluster-RCT (10,11,13,19,20).

Populations studied

All 12 studies included in this review involved children age 4–6.9 years at baseline or at the start of the intervention

Table 2 Theoretical model used in the development of interventions and level of parental involvement within intervention programmes

Theory	European Studies	Intervention techniques	Parental involvement
Social cognitive theory	Manios *et al.* (2002) (8)	Provide information on behaviour-health link; modelling; self-monitoring of behaviour; behavioural contracting, skill development; praise and reinforcement	High
Social learning theory	Warren *et al.* (2003) (18)	Provide information on behaviour-health link; incentives and reinforcement; skill development; a non-competitive environment for PA and opportunity to try new foods	Medium
	Bayer *et al.* (2009) (13)	Provide information on behaviour-health link; encourage parents and teachers to model healthy PA and dietary behaviour; create health-promoting environments for children	High
Health education model	Reilly *et al.* (2006) (10)	Increased school-based PA; provide information on behaviour-health link using posters in school and in providing a family resource pack	High
Socioecological conceptual model (Egger & Swinburn, 1997) (29).	Kriemler *et al.* (2010) (11)	Increase level of compulsory PA in school; children receive daily PA homework	Medium
None stated	Danielzik *et al.* (2007) (14)	Provide information on behaviour-health link; skill development; increased PA through running games	High
	Non-European Studies		
Self-determination theory	Fitzgibbon *et al.* (2006) (12)	Provide activities that promote choices related to food and physical activity: avoid coercion. Facilitate self-regulatory skills.	High
Social learning theory		Provide information on behaviour-health link; modelling to encourage exploration of new foods and try new activities; increase aerobic exercise through PA games in school	
Transtheoretical model/ stages of change		Target parents with information on behaviour-health link for themselves/their children; involve parents in PA sessions and classes on healthy eating	
Health belief model	Adams *et al.* (2008) (15)	Provide parents with information on behaviour-health link; support and encourage parents to provide healthy eating and active play opportunities for their children	High
Competence motivational theory		A games-based approach to movement skills development, to enable children to have fun and experience success developing skills	
Through schools approach	Graham *et al.* (2008) (19)	Aim to increase PA, reduce sedentary time and optimize nutritional intake through changes in the school environment and culture (e.g. promoting water intake in school, modify tuck-shop sales etc.)	Medium
None stated	Hu *et al.* (2010) (16)	Provide information on behaviour-health link through the provision of monthly nutrition classes for parents and their children, storybooks, pamphlets and health promotional posters within the kindergarten setting	High
None stated	Stock *et al.* (2007) (17)	A peer-led health promotion programme – provide information on behaviour-health link; lessons were delivered to kindergarten children by older children in the school on PA, nutrition and healthy body image	Low
None stated	Mo-Suwan *et al.* (1998) (20)	Intervention shaped by Superkids-Superfit Exercise Curriculum, which 'stresses non-competitive' activities as well as competitive sports, with the goal of increasing the amount of conditioning activity each child receives over the course of a school year (Harsha, 1995, p. 111).	Low

PA, physical activity.

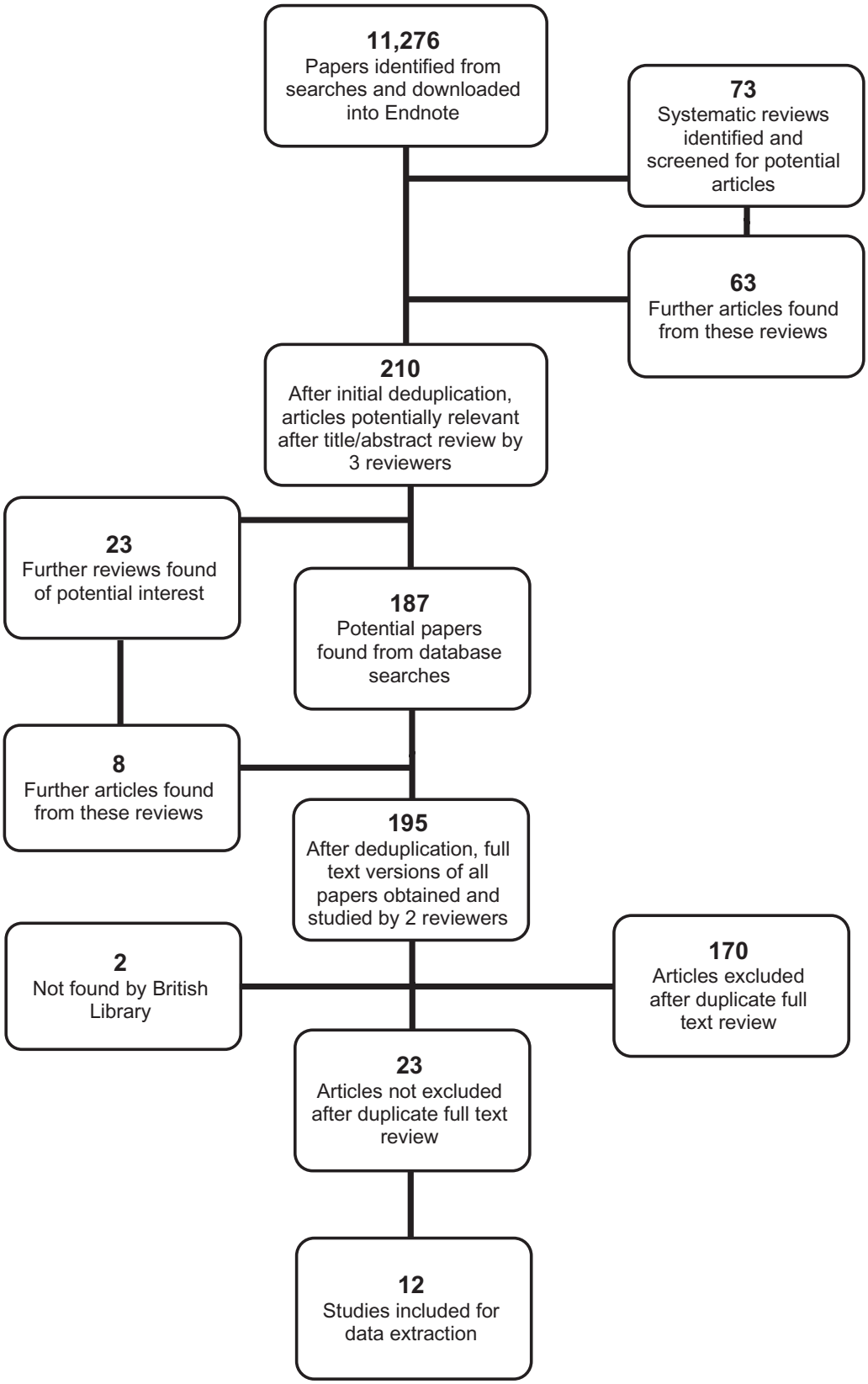

Figure 1 Flowchart of search.

Table 3 Impact of intervention on outcome measures

Study Ref/No.	European studies	QA	Model	PI	Weight	Dietary behaviour	PA behaviour	Determinants	Follow-up
(8)	Manios *et al.* (2002)	Strong	SCT	High	*	*	*	*	10 years
(18)	Warren *et al.* (2003)	Weak	SLT	Med	NS	NS	NS	*	14–16 months
(13)	Bayer *et al.* (2009)	Moderate	SLT	High	NS	*DU	NS	–	6 months (cohort 1)
					NS	*DU	NS	–	18 months (cohort 2)
(10)	Reilly *et al.* (2006)	Strong	HEM	High	NS	–	*	–	1 year
(11)	Kriemler *et al.* (2010)	Strong	SEC model	Med	*DU	–	*DU	NS DU	10 months
(14)	Danielzik *et al.* (2007)	Moderate	None reported	High	NS	NS	NS	–	4 years
Study Ref/No.	**Non-European studies**	**Q.A.**	**Model**	**P.I.**	**Weight**	**PA & dietary behaviour**		**Determinants**	**Longest follow-up**
(12)	Fitzgibbon *et al.* (2006)	Strong	SDT; SLT; TTM	High	*	*	NS	–	2 years (African-American cohort)
					NS	NS	NS	–	2 years (Latino Cohort)
(15)	Adams *et al.* (2008)	Moderate	HBM; CMT	High	*	*	*	–	9 months
(19)	Graham *et al.* (2008)	Weak	Through Schools Approach	Med	NS DU	NS DU	NS DU	*	2 years
(16)	Hu *et al.* (2010)	Moderate	None reported	High	NS	*	*	*	1 year
(17)	Stock *et al.* (2007)	Moderate	None reported	Low	NS	NS	NS	*	10 months
(20)	Mo-Suwan *et al.* (1998)	Weak	None reported	Low	NS	–	–	–	8 months

Longest follow-up times, theoretical models, quality assessment and parental involvement are also stated for each study.
*Significant results reported.
–, outcome not measured; DU, data unavailable; HBM, health belief model; HEM, health education model; NS, not significant results reported; QA, quality assessment rating; PI, parental involvement; SCT, social cognitive theory; SDT, self-determination theory; SEC, socioecological conceptual model; SLT, social learning theory; TTM, trans-theoretical/stages of change model.

programme. Studies were conducted in Europe (8,10, 11,13,14,18), North America (12,17), Asia (16,20) and Australasia (15,19). Although the focus was originally European, six non-European studies were included in the final review to allow the inclusion of potentially valuable information that these studies could provide. The intervention programmes were delivered within the preschool or school setting in all studies reviewed, with levels of parental involvement throughout the intervention period varying between studies. One study (14) had an additional family intervention component, which was offered to some families with overweight/obese children and/or parents, in addition to the preschool-based component. Parents in all the studies provided consent for their child or children to participate. Parents in 10 studies (8,10,12–16,18–20), provided data (usually by completing a questionnaire) as part of the intervention programme, either self-reported or reported on their children's behalf. Parents in seven of these studies also received components of the intervention programme (8,10,12–16), e.g. training and awareness-raising sessions were delivered to parents by interventionists, resources including healthy lifestyle messages were provided, and parents were often encouraged to find opportunities for increasing PA and/or healthy eating within the home.

Main target behaviours

Studies reported that interventions were developed to target key behaviours: to increase PA (11,20); to increase PA and healthy eating (8,12,13,15–18); to increase PA and reduce sedentary behaviour (10); and to increase PA and healthy eating, and reduce sedentary behaviour (14,19).

Body weight and adiposity (and associated risk factors)

All 12 studies included anthropometric outcome measures, reporting weight, BMI, BMI *z*-scores, weight or overweight/obese classification status, skinfold measurements, or waist circumference. For four studies, health risk indicators, including blood cholesterol, blood pressure or heart rate, were measured (8,11,17,19).

Dietary and physical activity behaviours

Nine studies included outcome measures of children's dietary behaviour reporting fruit and vegetable intake, intake of water and beverages, snacking behaviour, and nutrient intake (8,12–19). In two of these studies, parents' own dietary behaviours were also reported (12,16). Ten studies reported outcome measures of total PA, total moderate to vigorous PA, running and fitness tests, motor and movement skills, and/or sedentary behaviours (e.g. television [TV] viewing). Outcome measures for two studies did not include measures of PA change (16,20). In two studies, parents' PA and/or sedentary behaviours were self-reported (12,18).

Health awareness and parental modelling

Seven studies reported parents' and/or children's health knowledge, parents' attitudes to health, parental support and role modelling (8,11,14,16–19). In all but one (19) of these studies, cognitive variables (e.g. attitudes, knowledge), were primary outcome measures.

Interventions

Interventions varied in length of duration from up to (i) 6 months duration ($n = 3$) (10,12,14); (ii) 6 to 12 months duration ($n = 5$) (11,15–17,20); and (iii) more than 12 months duration ($n = 3$) (8,13,18). One other intervention programme was ongoing at the time of the review (19).

Length of follow-up

All but one (14) of the studies assessed intervention effects during and/or at the end of the intervention period. Four studies (8,10,12,14) also made follow-up assessments post-intervention (between 1 and 10 years from baseline).

Theoretical underpinning

Intervention development was guided by a variety of psychological models, with some interventions underpinned by more than one theory or model. The most common theory used was Bandura's (21–23) SCT/social learning theory (SLT). Four studies made explicit reference to these theories ([8]; SCT) and (12,13,18); SLT).

Six studies reported a single psychological model or theoretical framework guiding the intervention development (8,10,11,13,18,19), one study intervention was guided by two theoretical models (15), one study intervention was underpinned by three psychological models (12) and four studies did not report any theoretical basis for their intervention development (14,16,17,20), although an existing behaviour change programme did shape the intervention development in one of these studies (20). The theoretical models used can be seen in Table 3.

Parental involvement

For this review, the level of parental involvement within each study intervention was categorized as 'low' (parents provided consent only), 'medium' (parents provided [self-/child-] reported health questionnaires) and 'high' (parents were exposed to intervention components). Of the 12 studies, seven were rated as having 'high' parental involvement (8,10,12–16), three were rated as having 'medium' parental involvement (11,18,19) and two studies were rated as having 'low' parental involvement (17,20). Of the four studies that did not explicitly state any theoretical underpinning of the intervention programme, two studies were rated as having 'high' levels of parental involvement (14,16) and two were rated as 'low' (17,20).

Intervention effectiveness

Descriptions of behavioural models used and results for individual studies are reported in Tables 2 and Appendix 3, respectively. A summary of the results reported from all 12 studies included in this review is given later.

Weight status change

In four studies that reported favourable changes in weight status for children in the intervention group (8,11,12,15), all were categorized as having high or moderate parental involvement. In the four studies mentioned earlier, authors also reported favourable and significant effects of the intervention on PA and/or dietary behaviour change. Duration of follow-up varied for the studies reporting significant weight status change (9 months, 10 months, 2 years and 10 years follow-up), and follow-up time was equally variable (6 months to 4 years) for the eight studies reporting no significant intervention effects on weight status outcome measures (10,13,14,16–20). Of the four studies reporting a significant intervention effect on weight status, two reported the use of multiple (two or more) behavioural models in the development of the intervention programme (12,15), and two studies reported the use of a single model (8,11).

Physical activity and dietary behaviour change

In the seven studies reporting significant changes in PA and/or dietary behaviours at follow-up, one had a medium level of parental involvement (11) and six had high levels of parental involvement in the intervention programme (8,10–13,15,16); i.e., elements of the preschool- or school-based interventions were tailored and delivered to parents of intervention group children. Six of the seven studies reporting significant changes in PA and/or dietary behaviours discussed interventions that were underpinned by behavioural models (8,10–13,15). Of the five studies reporting no significant changes in PA and/or dietary behaviour, two interventions had high levels of parental involvement (12,14) (NB: for the Fitzgibbon *et al*. [2006] study (12), the non-significant results referred to here refer to the Latino cohort only) and three had medium and low levels (17–19). As expected, for the five studies reporting no significant intervention effect on PA and dietary behaviour, no significant change in weight status was reported either. It is important to note that of the 12 studies included in this review, nine used self-report as a tool for collecting either dietary, PA or sedentary behaviour data. Many of these were reported by parents on behalf of their children. Of the remaining three studies, one did not measure health behaviours (20) and two studies used objective tests to measure PA (10,11).

Changes in attitudes and knowledge. Four studies (8,16–18) reported significant changes for outcome measures of determinants of behaviour change (such as parents' and children's health knowledge, parents' attitudes to health, parental support and role modelling). Two of these studies reported the use of SCT/social learning theory (SLT) (21–23) in the development of the intervention programme (8,18). Two studies (16,17) did not report the use of behavioural models although there were elements common to all four intervention programmes: providing information on behaviour-health link; skill development; and modelling and reinforcement. Parental involvement was high or medium in three studies (8,16,18), and while parental involvement was low in the fourth study (17), the intervention programme was delivered in school to a young cohort of children by their older peers. To some extent, this supports claims that teachers, parents and older children can be useful role models in shaping young children's perceptions of healthy living.

In two studies (11,14), changes in knowledge and attitudes were not significantly altered by the intervention. For one study (19), data for cognitive measures were unavailable (authors were contacted but no response was received by the time of review submission). Changes in attitudes towards and knowledge of healthy behaviours were not outcome measures in five studies (10,12,13,15,20).

Behavioural models/theories underpinning intervention programmes

Eight studies reported using one or more behavioural model in the development of the intervention used (8,10–13,15,18,19). Of these studies, seven reported favourable intervention effects on at least one outcome measure (see Table 3). One (19) reported no intervention effect on outcome measures. The 'through schools approach' used in the development of this intervention allowed elements of the intervention to be individualized to each preschool on a 'school-needs' basis, and it is possible that the failure to find any intervention effects can be attributed to a low level of standardization of the intervention. Four studies did not report the use of behavioural models in the development of interventions used (14,16,17,20). Of these studies, two reported favourable intervention effects on at least one outcome measure (16,17).

Research of relevant studies conducted through the various stages of this review highlights the predominance of Bandura's (21–23) SCT/SLT in the development of interventions to prevent obesity in children of various ages. SCT describes behaviour change as an interaction between *personal*, *behavioural* and *environmental* factors. Skills, self-efficacy and outcome expectancies are the primary *personal* concepts within SCT for understanding behaviour change. Modelling, rewarding/reinforcement (from parents, teachers, carers and peers) and *availability* (e.g. provision of fruit within the preschool- or school-context) are the primary

environmental variables within SCT for understanding behaviour change. As young children are generally guided by parents and teachers in their dietary intake and levels/types of PA, Baranowski *et al*., suggest that 'environmental variables (e.g. parenting or availability) (as targets for interventions) offer the most promise with younger children' (24).

To some extent, the findings from this review support this view. Interventions that were developed using SCT/SLT incorporated personal and environmental intervention components such as providing opportunities for skills development (relating to dietary practices and PA activities for parents and children), or promoting self-efficacy (e.g. providing opportunities for children engaged in PAs to experience success or a sense of accomplishment). Outcome expectancies are likely to be shaped by children's knowledge and understanding of behaviour-health links. This component was present in the four interventions underpinned by SCT/SLT. Nevertheless, it is important to consider that interventions underpinned by other behavioural models or those that used no explicit theoretical models, also involved educational components – specifically the provision of information on behaviour-health links (see Table 3). Overall, there was consensus that parental involvement had been central to the success of the intervention programmes implemented, in terms of favourable and significant outcomes, trends in preferred directions and engagement and adherence to the intervention programme.

Important intervention components

In Table 3, outcome measures are presented as 'weight status changes' 'physical activity and dietary changes', and 'determinants of behaviour changes' and significant changes within these categories are also presented for each study.

Intervention strategies identified in five studies (8,11,12,15,16) that had significant results in two or more outcome measure categories are considered in the following section:

Duration of interventions and models used in development

Four of the intervention programmes were implemented for 1 year or more (8,11,15,16) with approximately 2 h or less of intervention contact time per week. In one study (12), the intervention was implemented for 14 weeks, with more than 2 h of intervention contact time per week, described as an intensive intervention delivered to children for 45 min, three times each week.

Interventions were underpinned by behavioural models in four studies (8,11,12,15): Bandura's (21–23) SCT/SLT (8,12), self-determination theory (25–27), trans-theoretical/stages of change model (TTM) (28) (aimed at parents) (12); one study (11) used the socioecological conceptual model (SEC) (29), and the HBM (30) combined with competence motivational theory (CMT) (31) in one study (15). Two studies used more than one behavioural model in the development of the intervention used (12,15), and in one study the authors did not report a theoretical underpinning to the intervention used (16).

Parental Involvement

The level of parental involvement within the intervention programmes with significant changes in all, or at least two of the three categories ('weight status changes', 'physical activity and dietary changes' and 'determinants of behaviour changes') was high in four studies (8,12,15,16) and moderate in one (11).

Education components

All five studies (8,11,12,15,16) had classroom-based components as part of the intervention programme, where information on behaviour-health links was provided to children and parents. Educational sessions were delivered as part of the intervention to children in the classroom, to parents in preschool- or school-based sessions; information on healthful behaviours was also provided in the form of flyers, booklets and homework for parents.

In the 'Cretan Health and Nutrition Education' programme (8) the intervention was designed to be teacher-delivered. Health and nutrition sessions were delivered to children (a total of 13–17 h over 1 year). Workbooks and teaching aids were developed specifically for the intervention. PA sessions (which had practical and theoretical components) were delivered by trained instructors (two 45-min sessions each week), in both the classroom and in the playground. Classroom modules were designed to develop behavioural capability, expectations and self-efficacy for healthful eating, PA and fitness. Parents attended meetings and presentations on topics relevant to dietary and exercising behaviours, and were encouraged to modify their own and their child's dietary and PA habits. Two parent meetings were held in school annually.

In the 'Nutrition education intervention' programme (16) interactive classes were delivered by trained graduate students and research assistants to children and parents, on the benefits of healthy diets and PA. Sessions delivered to children and their parents were informative regarding food preparation and cooking methods and were designed to facilitate skill development. The nutrition sessions were delivered monthly (eight sessions were implemented during the course of the 1-year intervention programme). Information was also provided to parents in the form of pamphlets and an illustrated book with a nutritional theme was distributed by teachers to all intervention group children.

Children in the 'Hip-Hop to Health Jr.' programme (12) took part in 45-min classes, three times per week for 14 weeks. Each session began with 5 min of warm-up exercises and was followed by a 20-min classroom-based activity related to healthy eating or exercise. Children spent the last 20 min of the session engaged in aerobic activity. The sessions were delivered by Head Start teachers. Parents also had an opportunity to attend 30-min aerobic sessions, twice each week for 14 weeks. They received newsletters informing them of the nutrition and PA sessions their children were involved in, and parents were asked to complete homework assignments each week on similar topics.

In the 'Tooty-Fruity Vegie' programme (15), health professionals (dieticians, health promotion officers or child and family health nurses) gave interactive workshops on positive parenting and healthy eating to parents. Parents were also encouraged to attend positive parenting courses, which were free or at reduced costs), and were provided with information and support at preschool-based workshops delivered by health professionals. Children were involved in interactive sessions with health professionals each term and teaching staff were trained and provided with a manual of ideas for including positive food messages in art, drama, role-play, music and stories. Preschool staff members were also trained to implement PA sessions: each session was repeated twice per week and each term was repeated twice for the duration of the 1-year programme.

Additional physical education (PE) lessons were delivered to children in the 'KISS' study (11) by 'expert PE teachers'. Two 45-min sessions were delivered each week in addition to their usual PE curriculum throughout the school year. Existing PE classes were delivered by their usual classroom teacher, who was present at the 'extra' classes for training purposes. Parents were not involved in school-based elements of the intervention but were provided with information in leaflets: families were encouraged to be physically active and children were encouraged to reduce TV/media time.

Interactive learning (diet and physical activity)

Learning about the behaviour-health link was also 'hands-on' throughout all five intervention programmes with significant results in the three categories of particular interest (8,11,12,15,16). Parents and children attended presentations and interactive sessions at preschool or school, and the interactive sessions with teachers, parents and children were offered as opportunities for skill development.

In all five studies, parents were given opportunities to learn more about healthy diets for their children (8,11,12,15,16). In two studies, parents and children were involved in interactive sessions aimed at facilitating skill development in food preparation and cooking (15,16) In one study, parents and children were encouraged to taste the foods prepared in the sessions and the children were also given the opportunity to grow their own vegetables (15).

PA was a component of all five interventions (8,11,12,15,16): in four studies (8,11,12,15), children were actively engaged in PA as part of the intervention programme (e.g. additional PE lessons, games and activities involving PA). Sessions in all five studies were developed to encourage children to try new healthful dietary and PA related behaviours and to promote skill development.

Targeting healthy eating and physical activity

The intervention targets in these studies were to increase PA and healthy eating (8,12,15,16) or to increase PA only (11). Nevertheless, although increased healthy eating was not a target of the latter intervention (11), all children and parents in the study were provided with nutritional information in the form of three flyers: general nutrition, vitamins and healthy snacks for preschool or school.

Discussion and conclusions

Not all of the 12 preschool- and school-based obesity preventions aimed at 4–6-year-olds that were identified in this systematic review reported using behavioural models. Of those that did ($n = 9$), SCT/SLT (21–23) was used most frequently in the development of intervention programmes ($n = 4$), either as a single model or in combination with other behavioural models. The other five intervention programmes used a variety of models; HBM and CMT (15), SEC (11), health education model (10), TTM (12).

Studies that used SCT/SLT in the development of the intervention (8,12,13,18) had significant favourable changes in one outcome measure category (13,18), two outcome measure categories (12) and in three outcome measure categories (8) (see Table 3 for further information). The key strategies of SCT/SLT that were used in the development of these interventions were modelling (observational learning) and techniques to facilitate skill development and increased self-efficacy. Parental involvement was high or medium in the studies that used SCT/SLT, and parents were encouraged to work with their children to facilitate healthful behaviour change through positive reinforcement, praise and modelling healthful behaviours themselves.

All 12 interventions included behaviour change strategies. Five of these studies had significant results in two or more outcome measures (8,11,12,15,16). Two of these studies used SCT/SLT (8,12), and one of these studies did not report using a behavioural model (16). These more successful studies were more likely to include high parental involvement, and the following behaviour change strategies:

1. Developing skills and behavioural capability;
2. Developing self-efficacy;
3. Educating parents and children (in classroom-based and/or practical sessions) about the benefits of healthful dietary and PA behaviours; and
4. Modelling healthful eating and PA.

A key element of these five interventions was *the development of children's perceived competence*, regarding making dietary and PA changes. Of interest, this behaviour change strategy is common to a number behavioural models aimed at behaviour change in children (and in parents): SCT/SLT (8,11,14,18), HBM (15), CMT (15) and SEC (11) here. In the intervention that was not explicitly underpinned by a behavioural model or theory (16), programme delivery targeted education, skills development and modelling healthful behaviours.

We suggest that the use of appropriate behavioural change strategies in interventions for preventing obesity in children aged 4–6-years-old is a key factor to the success of an intervention, rather than the use of specific behavioural models. Therefore, we suggest that in addition to high parental involvement and programmes targeting both dietary and PA changes, interventions also focus on developing children's (and parents') perceived competence at making dietary and physical changes, by implementing one or more of the four strategies identified earlier.

Targeting parents or caregivers within interventions was evident in 10 of the 12 studies in this review. Furthermore, a number of authors emphasized parental involvement as a key factor in the implementation of interventions aimed at changing children's health behaviours.

Finally, it is worth noting the potential bias of reporting positive outcome data by parents and carers in interventions that have significant parental involvement, and thus responsibility for success.

Recommendations for future research

Few interventions included in the present systematic review focused on changing the physical environments that shape children's health behaviour and development. As highlighted by the Foresight report (1) and others, there is a need to move beyond conducting more interventions that focus heavily on behavioural approaches aimed at the individual level, and develop interventions that focus on environmental, policy and community approaches that target population groups. The need to increase the evidence base that informs policy makers about the impact of changing the built environment on diet and PA behaviours is a high priority for research.

None of the interventions included in the present systematic review were informed by children's views. The Foresight report (1) highlighted the need for research that seeks to understand the value systems and social/cultural factors that drive human behaviour. Recent qualitative research conducted by Lanigan (32) provides a fresh perspective on the challenges and direction for obesity interventions that aim to improve young children's (3–5 years) knowledge, understanding, and behaviours associated with diet and PA. The need to ensure that the evidence base is driven by user involvement is a high priority.

Conflict of interest statement

None of the authors have any conflicts of interests to declare.

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Supporting Information

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

Appendix S1. References to included studies.
Appendix S2. Primary (1–20) and additional (21–32) references.
Appendix S3. Summary table of included studies.
Appendix S4. Excluded references.
Appendix S5. Systematic reviews assessed.
Appendix S6. Search strategies adopted.

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