THE JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY

ACAMH THE ASSOCIATION FOR CHILD AND ADOLESCENT MENTAL HEALTH

Journal of Child Psychology and Psychiatry 56:6 (2015), pp 677–692 doi:10.1111/jcpp.12330

Interventions aimed at reducing obesity in early childhood: a meta-analysis of programs that involve parents

H. Melis Yavuz,[1] Marinus H. van Ijzendoorn,[2] Judi Mesman,[1] and Shelley van der Veek[1]
[1]Department of Psycholog, Koc University, Istanbul, Turkey; [2]Centre for Child and Family studies, Leiden University, Leiden, The Netherlands

Background: Obesity is a growing problem even in very young childhood, resulting in high costs for individuals and society. As a response, numerous obesity prevention and intervention programs have been developed. Previous research has shown that early intervention programs are more effective when parents are involved, but the effectiveness of specific aspects of programs with parental involvement has not been investigated. This meta-analysis aims to investigate the features related to the effectiveness of different types of obesity intervention programs involving parents and targeting young children (0–6-year-olds). **Methods:** The Web of Science, PubMed, PsycInfo, CINAHL, and ERIC databases were searched for childhood obesity prevention and intervention programs involving parents. Data were analyzed using the Comprehensive Meta-analysis (CMA) software. **Results:** Fifty studies with effect sizes measured at short-term follow-up (within 3 months from the end of the intervention) and 26 studies with effect sizes measured at long-term follow-up (all reported in a total of 49 publications) were identified. The combined effect size of interventions was small but significant at short-term follow-up ($d = .08$, $p < .01$). The results suggested the presence of a potential publication bias in studies providing results at long-term follow-up, with a nonsignificant adjusted effect size ($d = .02$), which indicated that obesity interventions were not effective at long-term follow-up. Multivariate meta-regression analyses showed that interventions were more effective when including either interactive sessions or educational materials as opposed to those including both interactive sessions and noninteractive educational materials. No other moderators regarding sample characteristics, study design, or methodological quality were significant. **Conclusion:** Interventions targeting young children that require parental involvement are effective at short-term follow-up, specifically when interventions include one mode of intervention rather than two. However, results were not retained in the long run. **Keywords:** Obesity, intervention, prevention, parental involvement, meta-analysis, preschooler, infant.

Introduction

Over the last decades, the prevalence of overweight and obesity has increased drastically across the world, even in very young children (Wang & Lobstein, 2006), which is alarming as obesity in childhood is generally found to persist into adulthood (Magarey, Daniels, Boulton, & Cockington, 2003; Reilly et al., 2003), is linked to a host of physiological problems such as coronary heart diseases and premature mortality (Reilly & Kelly, 2011), and represents a major financial cost in health care systems (Withrow & Alter, 2010). Moreover, children with obesity have more problems with peers (Lumeng et al., 2010; Warschburger, 2005; Xie, Ishibashi, Lin, Peterson, & Susman, 2013) and are at risk for various forms of internalizing and externalizing psychopathological problems (Eschenbeck, Kohlmann, Dudey, & Schürholz, 2009; Halfon, Larson, & Slusser, 2013; Schwartz & Puhl, 2003). In childhood, parents are important in shaping obesity-related habits (Faith et al., 2012; Lindsay, Sussner, Kim, & Gortmaker, 2006), and several meta-analyses have shown that intervention programs involving parents are more effective in reducing childhood obesity than those that do not (e.g., Niemeier, Hektner, & Enger, 2012; Young, Northern, Lister, Drummond, & O'Brien, 2007). However, the programs with parental involvement show mixed effectiveness and it is not clear which aspects of the programs with parental involvement lead to more effective outcomes in young children, and meta-analyses have thus far not included studies on young children and/or did not provide information on the effectiveness of specific aspects of parental involvement (e.g., Stice, Shaw, & Marti, 2006; Wilfley et al., 2007). The current meta-analysis aims to examine the effectiveness of obesity interventions including parents and young children (0 to 6 years). The effectiveness of the intervention was calculated for both short-term (within 3 months from the end of the intervention) and long-term follow-up results. Moderators regarding intervention characteristics as well as sample and study characteristics are also examined.

Early childhood obesity has become a world-wide epidemic (Wang & Lobstein, 2006), and has become a major economic concern posing increased physical and psychological health care costs as well as non-health care costs like higher job-absenteeism and lower productivity (Finkelstein, Ruhm, & Kosa,

Conflict of interest statement: No conflicts declared.

Published by John Wiley & Sons Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA 02148, USA

2005). Given that obesity-related behaviors like consumption of energy-dense foods and beverages together with high levels of sedentary behaviors already start in early childhood (Certain & Kahn, 2002; Fox, Reidy, Novak, & Ziegler, 2006), it is vital to conduct intervention and prevention programs at an early age. Although cost-effectiveness analyses are generally not conducted for obesity interventions for young (0-5 year-old) children (see Bond, Wyatt, Lloyd, Welch, & Taylor, 2009; Hesketh & Campbell, 2010; Waters et al., 2011), obesity interventions for older children have been found to be cost-effective (e.g., Hollingworth et al., 2012). In fact, analyses taking lifetime economic costs and gains in terms of medical expenses and extended quality of life years (duration and quality of 'healthy life') into account suggest that making large investments in prevention/treatment programs for childhood obesity is cost-effective by widely accepted criteria (Trasande, 2010). More specifically, an intervention costing over 400 dollars per child would be cost-effective even if it reduces the prevalence of obesity in 6-year-olds by only one percent and increases the prevalence of overweight by that same one per cent (Trasande, 2010). Considering that early childhood interventions are generally claimed to be more cost-effective than interventions conducted with school-aged children or adults (Heckman, 2006), interventions in the very early years of life are likely to be most promising in this respect.

The development of obesity is related to various genes and genomic positions (Snyder et al., 2004), with estimates of 20% to 60% heritability (Maes, Neale, & Eaves, 1997), as well as metabolic and hormonal dysregulations (Speiser et al., 2005). However, there is evidence for gene–environment interactions predicting childhood obesity (Speiser et al., 2005), and the sharp increase in obesity over the past decades has not been accompanied by equally sharp changes in human gene pool, and metabolic dysregulations are generally found to be insufficient to explain the development of obesity (Weinsier, Hunter, Heini, Goran, & Sell, 1998). It is therefore necessary to take a closer look at factors in the environment that may help us understand the development of obesity in children, and the role of parenting is likely to be particularly salient in early childhood (Faith et al., 2012). Nevertheless, in Web of Science (July 6, 2014), only 1% of the publications on childhood overweight include the term 'parenting' in title or abstract, and 80% do not mention parents at all. Yet, parents are crucial in child weight-related behaviors in many ways. Parental feeding behaviors including high control over eating, structured feeding, sensitivity to child satiety cues, feeding as a response to hunger as opposed to general 'fussiness', as well as general parenting styles (e.g., authoritarian vs. authoritative parenting), and specific parenting behaviors (e.g., modeling, reinforcement, goal setting) have all been linked to concurrent and later child obesity-related behaviors (Birch & Ventura, 2009; Gerards, Sleddens, Dagnelie, de Vries, & Kremers, 2011; Harrist et al., 2012; Jeor, Perumean-Chaney, Sigman-Grant, Williams, & Foreyt, 2002; Lindsay et al., 2006). For these reasons, interventions with parental involvement might be promising in decreasing childhood obesity. However, there is high heterogeneity among interventions with parental involvement in terms of the content of the interventions as well as the outcomes that were measured and the factors that are related to increased effectiveness within these interventions are not clear. The most salient factors that may relate to intervention effectiveness include intervention focus, type of intervention delivery, sample characteristics, and study characteristics, discussed below.

First, the focus of interventions targeting parents can be categorized into three broad types of behaviors that also co-occur within programs: (a) general parenting skills/behaviors (e.g., modeling, monitoring, reinforcement, setting goals), (b) diet/nutrition related behaviors, (c) physical activity/sedentary behaviors. In the literature, there is no consensus as to whether one type of intervention is more effective than the others (see Hingle, O'Connor, Dave, & Baranowski, 2010; Sung-Chan, Sung, Zhao, & Brownson, 2013). However, a meta-analysis showed that general parental behavior modification training was effective after controlling for parenting education regarding nutrition and food preparation (Kitzman et al., 2010). Therefore, we hypothesize that the inclusion of a general parenting skill or behavior component in early childhood obesity interventions would be related to increased intervention effectiveness.

Second, childhood obesity interventions are delivered in either one or both of two ways, (a) receiving interactive sessions, (b) receiving noninteractive educational materials. Both significant and nonsignificant program effectiveness have been found in interventions that required parents and/or children to participate in interactive sessions (e.g., De Bock, Breitenstein, & Fischer, 2012; Stark et al., 2011), or that provided both interactive sessions and educational materials to the participants (e.g., Bellows, Davies, Anderson, & Kennedy, 2013; Verbestel et al., 2014). We hypothesize that receiving interactive sessions were more effective than receiving only noninteractive educational materials, as interactive sessions would be more intense and provide more opportunities for questions from participants and clarification of intervention objectives.

Third, divergent findings regarding the effectiveness of obesity interventions might also result from the characteristics of the sample, including child age, gender, minority status, as well as baseline weight status of the child and parent. Early intervention programs initiated in the preschool years have been suggested to be more effective than later (childhood or adolescence) interventions (Heckman, 2006). Yet, there is no evidence for superiority of early interventions starting in infancy as opposed to the preschool years, therefore no age differences within early childhood were hypothesized. The literature suggests no gender effect for young children (Waters et al., 2011), and participant ethnicity also was not found to be a significant moderator in a previous meta-analysis (Stice et al., 2006). Therefore, we did not hypothesize differential effectiveness of interventions regarding age, gender, and minority status. Baseline weight of children and parents, however, might be related to intervention effectiveness. However, previous studies investigating this moderator yielded mixed results regarding eating disorders and obesity (Stice & Shaw, 2004; Stice et al., 2006). Thus, no specific hypotheses about relative effectiveness of targeted versus universal interventions were formed. Finally, regarding study characteristics, longer interventions have been found to be more effective than shorter ones, possibly because they allow program content to be repeated, and allow participants to reflect upon, tryout, and internalize program materials (Campbell & Hesketh, 2007; Stice & Shaw, 2004), but longer interventions have also been found to be less effective than shorter ones, maybe because they increase drop-out rates and decrease effectiveness (Stice et al., 2006). Given these contradictory results, in the current meta-analysis, the role of duration of intervention on intervention effectiveness was examined without a specific hypothesis.

Method

Selection of studies

Intervention studies as reported in journal articles and dissertations were retrieved via three different search strategies. First, the electronic databases Web of Science, PubMed, PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and ERIC were searched, until June 2013, using the following keywords (obesity OR obese OR overweight) AND (intervent* OR prevent* OR treat* OR therap* OR behavior modification OR health education OR weight reduct* OR lifestyle OR program*) AND (random OR randomized control* trial OR randomised control* trial OR RCT OR assign*) AND (child* OR youth OR infant OR infants OR infancy OR preschool* OR baby OR babies). This search yielded 3,715 hits after removing duplicates.

Studies were included if they (a) test the effectiveness of a preventive intervention or treatment intervention program, (b) on a weight-related outcome (e.g., BMI, zBMI, percentage overweight and/or obesity), (c) using a randomized controlled trial design (cluster randomized trials were also included), (d) conducted with children up to 6 years old at baseline, (e) with levels or types of parental involvement that vary between the intervention and control groups. As studies conducted with infants generally provided weight-for-height information, weight and weight-for-height were also accepted as a weight-related outcome, but only for infancy studies. Studies were excluded if (a) they were conducted with children with intellectual disabilities (e.g., mental retardation, genetic syndromes), (b) they investigated the effect of a specific type of controlled-diet (e.g., high vs. low protein), and (c) they were not published in English. We defined parental involvement as either one or a combination of (a) parents receiving noninteractive educational materials, and/or (b) parents participating in interactive sessions. Studies providing only an information session about the intervention to parents or only requiring parents to sign the consent form were not included. This procedure yielded 48 publications reporting on 74 effect sizes.

Our second search strategy was to screen the reference lists of the selected empirical studies and previous relevant reviews and meta-analyses retrieved from the electronic data base search, by using the same inclusion and exclusion criteria as mentioned above. One additional study was identified in the reference lists of the selected studies, while the reference lists of the reviews and meta-analyses did not yield additional results. Finally, we conducted another search within the same data bases as mentioned above to find other meta-analyses about childhood obesity. We used the following keywords: (obesity OR obese OR overweight) AND (meta-analysis OR metaanalysis) AND (parent*) AND (child*). This search yielded five relevant meta-analyses. Their reference lists were screened to find additional studies that met our inclusion criteria, but none were found. Thus, our final set consisted of 49 publications with 76 eligible unique effect sizes (see detailed descriptions of reasons for exclusion in Figure 1). Studies were coded for short-term and long-term follow-up results separately and Tables 1 and 2 provide overviews of the included studies for short-term and long-term follow-up results, respectively.

The selection of the studies was conducted by three researchers (first and last author, and a research assistant). For reliability purposes, we screened 50 articles regarding the inclusion and exclusion criteria. Agreement between the three researchers ranged from 92% to 96%.

Coding system

The coding system that was used to rate studies on *sample characteristic*, *study design*, and *methodological quality* is presented in Table 3. For *sample characteristics*, demographic information from the sample, including sample size (at outcome), child age (at the beginning of the intervention), baseline overweight-obesity status of the child and the mother, percentage of female children and minorities in the sample, and the geographical area in which the data was collected were coded.

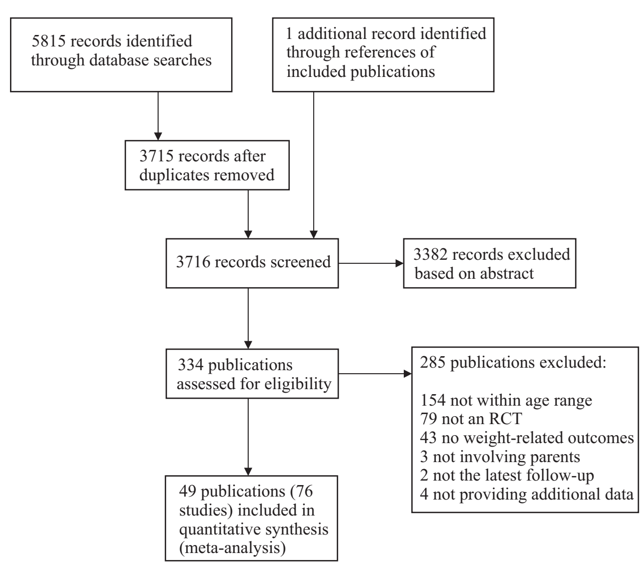

Figure 1 Flow chart illustrating of the inclusion and exclusion of publications

Table 1 Coding system for rating intervention studies

Variable	Coding system
Sample characteristics	
Sample size[a]	Number of participants with information at post-test
Child age at baseline in years	1 = Before birth (during pregnancy) and infancy (0-12 months) 2 = Toddler and Preschooler (13-78 months)
Classification of baseline weight[b,c]	1 = Obese (OB) and Overweight (OW) 2 = Mixed (OB-OW and normal weight) 3 = Nonobese
Gender ratio (% girls)[c]	1 = Less than or equal to 20% girls 2 = Between 21% and 79% girls 3 = More than or equal to 80% girls
Racial make-up (% minority)[c]	1 = Less than 20% minority 2 = Between 21% and 79% minority 3 = More than 80% minority
Continent	1 = North America (USA- Canada) 2 = Europe 3 = Other (Latin America, Asia, Australia)
Study design	
Duration of the intervention (in months)[c]	1 = 6 months or less 2 = Between 7 and 12 months 3 = Between 13 and 24 months 4 = 25 months or more
Follow-up interval (in months)[d]	1 = 11 months or less 2 = Between 12–36 months 3 = 37 months or more
Control group received	1 = Dummy intervention 2 = No intervention
Content of intervention	1 = Focused on general skills 2 = Focused on eating habits/physical activity 3 = Mixed
Mode of delivery of intervention	1 = Interactive only (e.g., face-to-face sessions, phone calls) 2 = Noninteractive only (e.g., educational materials, websites) 3 = Mixed (i.e., both interactive sessions and noninteractive educational materials)
Intervention provided to	1 = Parent only 2 = Parent and child
Methodological quality	
Blinding[c]	1 = Blind 2 = Not blind
Difference in baseline weight-related data[c]	1 = Significant difference between IG and CG 2 = Nonsignificant difference between IG and CG

IG, intervention group; CG, control group.
[a]When there were more than one intervention groups, the sample size of the control group was split up according to the number of intervention groups.
[b]Separately coded for mothers and children.
[c]When no information was provided, it was coded as not reported.
[d]Coded only for interventions with available long-term follow-up data. When there are multiple long-term follow-up results, the information from the latest follow-up was coded.

For *study design*, we coded the duration of the intervention in months, the timing of the outcome assessment (short-term or long-term follow-up), follow-up interval (the time between the end of the intervention and the assessment of the outcome, coded for articles with follow-up information only), presence or absence of a dummy intervention (either on obesity-related behaviors or not) in the control group, content of the intervention (only general skills intervention, only eating habits/physical activity intervention, or mixed), mode of delivery of the intervention (interactive sessions, noninteractive educational materials, or both), and the target of the intervention (parent or parent and child). For the content of the intervention we coded the behaviors targeted to change within the intervention. We coded 'general skills' as general parent–child interactive behaviors and skills including (a) general parenting behaviors (e.g., praise, modeling, reinforcement, monitoring, being sensitive to infant cues, calming down an infant), and (b) general parenting skills (e.g., goal setting, self-efficacy, problem solving, conflict resolution, cognitive restructuring, sleep management). We coded 'eating habits/physical activity intervention' when interventions provide informative interactive sessions either to parents, to children, or both, on eating behaviors (e.g., diet, nutrition) or physical activity/sedentary behaviors, and when interventions are aimed at changing eating, physical activity and/or sedentary behaviors. The 'mixed' category included interventions that provided both general skills and eating habits/physical activity interventions. For the mode of delivery of the intervention, we coded how the intervention was delivered to parents and children. We coded 'interactive sessions' if parents and/or children in the intervention group received face-to-face sessions with an intervener, or they have received training/intervention through phone calls about childhood obesity. We coded 'non-interactive educational materials' when parents received educational materials (e.g., pamphlets, educational web-sites) about childhood obesity. If parents and/or children received both inter-

Table 2 Intervention studies: descriptives and effect sizes for studies providing results at short-term follow-up

Study	N	Duration of intervention (months)	Baseline Age[a]	Child Baseline Weight	Content[b]	Mode of delivery	Effect of intervention		
							d	95% CI	p
Barkin et al. (2012)	75	3	2	Mixed	3	Interactive only	.77	.30, 1.24	.00
Bayer et al. (2009, sample 1)	1,295	6	2	NR	3	Mixed	.13	.02, .24	.02
Bayer et al. (2009, sample 2)	1,326	18	2	NR	3	Mixed	.03	−.08, .14	.61
Bellows et al. (2013)	201	4.5	2	Mixed	3	Mixed	.00	−.28, .28	1.00
Berry et al. (2011)	56	6	2	NR	3	Interactive only	.69	.14, 1.23	.01
Bocca et al. (2012)	62	4	2	OB-OW	1	Interactive only	.52	.01, 1.03	.05
Campbell et al. (2013)	457	15	1	Mixed	3	Mixed	−.10	−.28, .08	.29
Cespedes et al. (2013)	1,116	5	2	Mixed	3	Mixed	.12	−.00, .23	.06
Crespo et al. (2012, IG 1)[c]	173	36	2	Mixed	3	Mixed	−.03	−.38, .33	.88
Crespo et al. (2012, IG 2)[c]	141	36	2	Mixed	3	Interactive only	−.02	−.36, .32	.91
Crespo et al. (2012, IG 3)[c]	128	36	2	Mixed	3	Mixed	.02	−.34, .38	.92
De Bock et al. (2012)	202	6	2	NR	3	Interactive only	.00	−.28, .28	1.00
De Coen et al. (2012)	1,112	18	2	NR	3	Mixed	.03	−.09, .15	.61
Dennison et al. (2004)	77	18	2	NR	3	Mixed	.21	−.24, .66	.35
Epstein et al. (2008)	67	24	2	OB-OW	3	Non-interactive	.06	−.42, .54	.82
Fitzgibbon et al. (2005)	362	3.5	2	Mixed	2	Mixed	.00	−.21, .21	1.00
Fitzgibbon et al. (2006)	383	3.5	2	Mixed	2	Mixed	.00	−.20, .20	1.00
Fitzgibbon et al. (2011)	589	3.5	2	Mixed	2	Mixed	.05	−.11, .21	.56
Fitzgibbon et al. (2013)	143	3.5	2	Mixed	3	Mixed	−.05	−.38, .28	.78
French et al. (2012, IG 1)[d]	93	12	1	Mixed	1	Mixed	−.05	−.48, .38	.82
French et al. (2012, IG 2)[d]	91	12	1	Mixed	3	Mixed	−.41	−.84, .02	.06
Hakanen et al. (2006, boys)[e]	303	43.5	1	Mixed	3	Interactive only	.02	−.21, .24	.89
Hakanen et al. (2006, girls)[e]	282	43.5	1	Mixed	3	Interactive only	.25	.01, .48	.04
Harvey-Berino & Rourke (2013)	40	4	1	Mixed	2	Interactive only	.43	−.20, 1.06	.18
Jouret et al. (2009)	1,253	24	2	Mixed	2	Mixed	.04	−.07, .15	.50
Karanja et al. (2010)	177	28.5	1	Mixed	2	Interactive only	.41	.09, .73	.01
Kavanagh et al. (2008)	38	.03	1	Mixed	1	Non-interactive	−.31	−.95, .33	.35
Llargues et al. (2011)	504	18	2	Mixed	2	Mixed	.06	−.12, .24	.50
Louzada et al. (2012, boys)	223	12	1	Mixed	3	Interactive only	.05	−.22, .31	.73
Louzada et al. (2012, girls)	173	12	1	Mixed	3	Interactive only	.05	−.26, .35	.77
Nemet et al. (2011[a], boys)	393	9	2	Mixed	2	Mixed	.10	−.09, .30	.30
Nemet et al. (2011[a], girls)	332	9	2	Mixed	2	Mixed	.06	−.16, .27	.61
Nemet et al. (2011[b], boys)	167	9	2	Mixed	2	Mixed	.50	.19, .81	.00
Nemet et al. (2011[b], girls)	130	9	2	Mixed	2	Mixed	.35	−.00, .69	.05
Østbye et al. (2012)	301	8	2	Mixed	3	Mixed	−.08	−.31, .15	.48
Puder et al. (2011)	625	9	2	NR	3	Mixed	.03	−.13, .18	.75
Quattrin et al. (2012)	96	6	2	OB-OW	1	Interactive only	.69	.28, 1.11	.00
Reilly et al. (2006, boys)	244	6	2	Mixed	2	Mixed	.02	−.23, .27	.88
Reilly et al. (2006, girls)	237	6	2	Mixed	2	Mixed	−.12	−.38, .13	.35
Rush et al. (2012)	926	24	2	Mixed	2	Interactive only	−.04	−.17, .09	.53
Small et al. (2013)	60	4	2	OB-OW	3	Mixed	.42	−.10, .93	.11
Stark et al. (2011)	17	6	2	OB-OW	1	Interactive only	1.74	.61, 2.87	.00
Story et al. (2012)	440	18	2	Mixed	3	Mixed	.01	−.18, .19	.95
Taveras et al. (2011)	445	12	2	OB-OW	3	Mixed	.07	−.12, .26	.45
Verbestel et al. (2014)	153	12	1	*Not* OB-OW	3	Non-interactive	.55	.22, .89	.00
Warren et al. (2003, IG 1)[f]	56	14	2	Mixed	3	Mixed	.00	−.61, .61	1.00
Warren et al. (2003, IG 2)[f]	60	14	2	Mixed	3	Mixed	.00	−.60, .60	1.00
Warren et al. (2003, IG 3)[f]	56	14	2	Mixed	3	Mixed	.00	−.61, .61	1.00
Wen et al. (2012)	483	24	1	Mixed	2	Interactive only	.15	−.03, .33	.09
Zask et al. (2012)	438	10	2	NR	3	Mixed	.09	−.10, .28	.36

OB, obese; OW, overweight; NR, not reported; IG, intervention group.
[a]1 = Before birth, Infant; 2 = Toddler-Preschooler.
[b]1 = General parenting; 2 = Eating habits/physical activity; 3 = Mixed.
[c]IG 1 = School/Community only; IG 2 = Family only; IG 3 = Both (Crespo et al., 2012).
[d]IG 1 = Maternal-focused intervention; IG 2 = Ounce of prevention (French et al., 2012).
[e]The exceptionally long duration of intervention (120 months) reported by Hakanen et al. (2006) was Winsorized (to N = 43.5) to avoid disproportionate influence of this duration on analyses.
[f]IG 1 = Eat smart; IG 2 = Play smart; IG 3 = Eat smart, play smart (Warren et al., 2003).

Table 3 Intervention studies: Descriptives and effect sizes for studies providing long-term follow-up results

Study	N	Duration of intervention (months)	Baseline Age[a]	Child Baseline Weight	Content[b]	Mode of delivery	Effect of intervention		
							d	95% CI	p
Birken et al. (2012)	132	.03	2	NR	3	Mixed	.12	−.22, .46	.50
Bocca et al. (2012)	57	4	2	OB-OW	1	Interactive only	.67	.13, 1.21	.01
Brotman et al. (2012, study 1)	40	6	2	NR	1	Interactive only	.51	−.14, 1.16	.12
Brotman et al. (2012, study 2)	146	6	2	NR	1	Mixed	.56	.20, .91	.00
Cespedes et al. (2013)	596	5	2	Mixed	2	Mixed	−.06	−.22, .11	.50
De Bock et al. (2012)	202	6	2	NR	3	Interactive only	.00	−.28, .28	1.00
Fitzgibbon et al. (2005)	300	3.5	2	Mixed	2	Mixed	.23	.01,. 46	.05
Fitzgibbon et al. (2006)	331	3.5	2	Mixed	2	Mixed	.07	−.15, .28	.55
Fitzgibbon et al. (2013)	128	3.5	2	Mixed	3	Mixed	−.05	−.39, .30	.80
Llargues et al. (2012, boys)	220	18	2	Mixed	2	Mixed	.19	−.08, .46	.16
Llargues et al. (2012, girls)	204	18	2	Mixed	2	Mixed	.02	−.25, .30	.87
Louzada et al. (2012, boys)	175	12	1	Mixed	3	Interactive only	.05	−.25, .35	.74
Louzada et al. (2012, girls)	133	12	1	Mixed	3	Interactive only	.11	−.23,.45	.53
Martin et al. (2013)[c]	1,788	NR	1	Mixed	2	Interactive only	−.06	−.15, .04	.24
Nemet et al. (2013)	203	9	2	Mixed	2	Mixed	.28	−.01, .56	.05
Paul et al. (2011, IG 1)[d]	39	5	1	Mixed	3	Mixed	−.25	−.97, .47	.49
Paul et al. (2011, IG 2)[d]	39	5	1	Mixed	1	Mixed	−.03	−.75, .69	.94
Paul et al. (2011, IG 3)[d]	32	5	1	Mixed	3	Mixed	.55	−.21, 1.31	.16
Plachta-Danielzik et al. (2011)	1,192	4.5	2	NR	2	Interactive only	.02	−.09, .13	.72
Reilly et al. (2006, boys)	247	6	2	Mixed	2	Mixed	.13	−.12, .38	.31
Reilly et al. (2006, girls)	248	6	2	Mixed	2	Mixed	−.11	−.36, .14	.38
Scheiwe et al. (2010)	86	9	1	Mixed	2	Interactive only	−.15	−.57, .28	.50
Slusser et al. (2012)	81	4	2	Mixed	3	Mixed	.25	−.19, .70	.26
Small et al. (2013)	60	4	2	OB-OW	3	Mixed	.19	−.32, .70	.47
Stark et al. (2011)	16	6	2	OB-OW	1	Interactive only	1.68	.54, 2.83	.00
Wake et al. (2011)	193	2	1	Mixed	1	Mixed	−.09	−.38, .19	.52

OB, obese; OW, overweight; NR, not reported; IG, intervention group.
[a]1 = Before birth, Infant; 2 = Toddler- Preschooler.
[b]1 = General parenting; 2 = Eating habits/physical activity; 3 = Mixed.
[c]The exceptionally large sample size (N = 13,879) reported by Martin et al. (2013) was Winsorized (to N = 1,788) to avoid disproportionate influence of this sample size on analyses.
[d]IG 1 = Introduction of solids; IG 2 = Soothe/Sleep; IG 3 = Both (Paul et al., 2011).

active sessions and noninteractive educational materials, we coded these studies as 'both'. If the control group received a dummy intervention, then the components that were provided only to the intervention group were coded as constituting the intervention program.

For the *methodological quality* of the studies, we coded whether or not the provider of the outcome information was blind to participants' group assignment, and whether or not there were significant differences between intervention and control groups on baseline weight-related information (either provided by the study authors or calculated based on the available information provided in text or tables).

There were also a number of other possible moderators that were coded but could not be used for the analyses because there was not enough variance between studies as indicated by less than four studies in a subcategory or because the information provided by studies were inconsistent and could not be categorized. An example of a low-variance moderator is the presence (reported in 4% of the studies) versus the absence (reported in 20% of the studies) of differential attrition rates between the intervention and control groups. Examples of inconsistently reported moderators are parental education level and socioeconomic status. Moreover, the presence or absence of information on child baseline weight was also coded for each study as an indicator of methodological quality. Yet, this information was present in 47 out of 50 studies in short-term follow-up, and 22 of 26 studies in long-term follow-up. As there was no sufficient variance in this moderator with most studies including this information, this moderator was not included in the analyses.

For selection of the publications, we focused exclusively on those reporting on programs in which participants were randomly assigned to the intervention and control groups. There were two studies in which the participants were randomly assigned across intervention groups but the participants in the control group were not randomly assigned (Jouret et al., 2009; Karanja et al., 2010). In these cases, the group receiving the lowest level of intervention in terms of duration and content was coded as the control group, and the other intervention group(s) receiving higher levels of intervention duration and content was coded as the intervention group(s). When a publication did not provide sufficiently detailed information about the intervention program, supplementary publications on the same intervention (e.g., study protocols) were retrieved for further information. If multiple follow-up results of the same intervention were published, the results with short-term follow-up information and with the longest follow-up period were selected for comparing the effect of time on the efficacy of the intervention programs.

The moderators were coded by two coders (first author and a research assistant). Intercoder reliability among the coders was established by coding 25 articles (for the first 15 articles, all items were coded, for the next 10 articles, only specific items for which reliability was unsatisfactory because of restricted variation in the first set were coded). The Kappa values for agreement were > .80 for categorical variables and intraclass correlations were >.70 for continuous variables. Disagreements were resolved via discussions among coders and when necessary, they were discussed with a third researcher (the last author) until a consensus was reached.

Statistical analyses

The effect sizes (Cohen's *d*) for the meta-analysis and the 95% confidence intervals around the point estimates of effect sizes were calculated using the Comprehensive Meta-Analysis (CMA) program (Borenstein, Rothstein, & Cohen, 2005). When a study reported more than one weight-related outcome (e.g., BMI and percentage of obese children), these outcomes were meta-analytically combined into one effect size. When a study provided information on two different interventions or samples, separate effect sizes were computed for each intervention or sample. Likewise, when a study reported results for boys and girls separately, the results for these sub-samples were considered to reflect the outcomes of two studies. Some interventions provided results for more than one intervention group. In that case, the information on all intervention groups was retained and analyzed independently, and the sample size in the control group was divided by the number of intervention groups to prevent participants being included in the analyses more than once. When an effect was congruent with the hypothesis (e.g., higher decrease in BMI in the intervention group compared to the control group), it was assigned a positive sign. When the effect was incongruent with the hypothesis, it was assigned a negative sign. Studies that did not report exact statistical information on the significance of the results were assigned a conservative nonsignificant *p* value of .50 (Mullen, 1989). Two effect sizes for short- and long-term follow-ups were calculated separately to examine effectiveness at short- and long-term.

The significance of effect sizes and moderators were analyzed by random effects models (Borenstein, Hedges, & Rothstein, 2007). In contrast to fixed effects models, random effects models allow for random variation in the size of the effect due to differences in procedures, measures or settings across studies (Borenstein et al., 2007; Lipsey & Wilson, 2001). Moreover, when the assumption of homogeneity is not met, random effects model adequately reflect the heterogeneity in the studies without inflating the alpha levels. *Q*-statistics (*Q*h) were computed to test the homogeneity of the moderator variables (Borenstein et al., 2005). Contrast *Q*-statistics (*Q*c) were computed to assess differences in effect sizes of subsets within a moderator. *Q*c-statistics were only computed when there was a minimum of two subsets containing at least four studies to avoid reaching conclusions based on small sample sizes (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003, 2005).

To address a possible publication bias, funnel plots and fail-safe numbers were examined separately for studies providing short- and long-term follow-up results. A funnel plot is a plot of each study based on its effect size and standard error (usually plotted as $1/SE$ or precision). The plot is expected to show a funnel shape with a symmetrical distribution on the right and left side of the mean if there is no publication bias. However, smaller studies with nonsignificant results are less likely to be published and in the case of such a publication bias, the bottom left-hand corner of the funnel plot is not symmetrical with the bottom right-hand corner (Duval & Tweedie, 2000b; Sutton, Duval, Tweedie, Abrams, & Jones, 2000). The degree of asymmetry is examined by the number of studies that have no symmetric counterpart on the other side of the funnel plot. The 'trim and fill' method which trims the symmetrically unmatched studies and imputes (fills) their symmetrical counterparts, is used for analyzing the influence of a possible publication bias. The trim and fill method also allows for the computation of adjusted effect size and confidence intervals with the imputed values (Gilbody, Song, Eastwood, & Sutton, 2000; Sutton et al., 2000). The fail-safe *N* represents the number of studies required to nullify the intervention effect.

Results

The current meta-analysis included 50 studies (total *N* = 16,801) providing effect sizes at short-term follow-up (within 3 months) and 26 studies (total *N* = 6,888) providing effect sizes at long-term follow-up (reported in 49 publications). Tables 2 and 3 provide overviews of the studies and basic characteristics of studies including effect sizes at short-term and long-term follow-ups, respectively. The sample sizes of the selected studies ranged from 17 to 1,788 (with winsorized sample size of the outlying study by Martin et al., 2013) and publication dates ranged from 2003 to 2013. Interventions were mostly conducted with toddlers and preschool children (75%) and most of the interventions were universal (68%) rather than targeting children who are obese or overweight. Many of the interventions were conducted in North America (46%) followed by Europe (29%) and other countries (25%) and usually lasted 12 months or less (75%).

The results of the meta-analyses of short- and long-term follow-up outcomes are presented in Tables 4 and 5, respectively. Overall, the interventions were related to decreases in weight-related outcomes in children. The combined effect size of interventions in child obesity-related outcomes were small but significant both at short-term follow-up ($d = .08$, 95% CI = .04, .13, $p < .01$) and at long-term follow-up ($d = .09$, 95% CI = .01, .16, $p < .05$). Both sets of studies were heterogeneous (with $Q\text{h} = 85.64$, $p < .001$ for short-term follow-up and $Q\text{h} = 43.41$, $p < .05$ for long-term follow-up results). Based on the results of the trim and fill method, there was no evidence for a publication bias in studies providing short-term follow-up results, i.e., no studies needed to be trimmed and filled (Duval & Tweedie, 2000a, b) (Figure 2). The fail-safe *N* was also high ($N = 318$), indicating that more than 300 null results would be required to cancel out the combined effect size (Mullen, 1989). The presence of some asymmetry in the funnel plot and the trim and fill results did indicate a potential publication bias in studies providing results at long-term follow-up (7 studies had to be trimmed and filled; Figure 2). Moreover, the fail-safe *N* was lower than the threshold suggested by Rosenthal (1995), i.e., $5k + 10$, with 52 studies required to nullify the effect size. It should, however, be noted that in this relatively new field of inquiry with only 50 studies in total, 26 of which reported long-term effects, it seems doubtful that more than 24 studies can be found not reporting follow-up results because of null findings. After trim and fill, the adjusted effect size for follow-up studies was .02, and nonsignificant (95% CI = −.07–.11,

Table 4 Meta-analytic results of randomized interventions at short-term follow-up (k = 50 Study outcomes)

	K	N	Cohen's d	p	95% CI	Q Heterogeneity	Q Contrast	p Contrast
Total set	50	16,801	.08	.00	.04, .13	85.64***		
BMI-related outcomes only[1]	42	11,020	.10	.00	.04, .16	85.07***		
Sample characteristics								
Child age								
Before birth and Infancy	12	2,513	.10	.06	−.01, .20	25.97**	.01	.76
Toddler/Preschool	38	14,288	.08	.00	.03, .13	59.30*		
Child baseline weight[2]								
OB and OW	6	747	.29[a]	.00	.12, .47	16.68**	6.50	.04
Mixed	35	10,770	.05[b]	.04	.00, .11	46.52		
Nonobese	1	153	.55	.00	.18, .93	.00		
NR	8	5,131	.08[b]	.09	−.02, .17	8.16		
Parent baseline weight								
OB and OW	6	548	.25	.02	.05, .45	24.70***	3.07	.22
Mixed	12	2,334	.05	.37	−.06, .16	16.20		
NR	32	13,919	.08	.00	.03, .13	42.56		
% Girls[2]								
≤20% girls	5	1,330	.12	.10	−.02, .26	7.60	.55	.76
21%–79% girls	38	13,657	.07	.01	.01, .12	65.08**		
≥80% girls	5	1,154	.10	.18	−.05, .25	6.52		
NR	2	660	.24	.03	.02, .45	1.83		
% Minority in sample								
≤20% minority	8	3,391	.09	.14	−.03, .22	10.61	2.62	.46
21%–79% minority	13	4,047	.03	.55	−.06, .12	22.22*		
≥80% minority	11	2,530	.07	.19	−.04, .18	17.13		
NR	18	6,833	.12	.00	.05, .20	31.28*		
Continent								
North America	23	4,193	.09	.03	.01, .17	49.20***	.06	.97
Europe	15	7,266	.08	.07	−.01, .16	18.66		
Other	12	5,342	.09	.04	.01, .17	17.72		
Study design								
Duration of intervention								
6 months or less	18	5,216	.12	.01	.04, .20	42.80***	1.97	.58
7–12 months	14	4,490	.08	.07	−.01, .16	27.82**		
13–24 months	12	5,891	.04	.42	−.05, .13	4.60		
25 months or more	6	1,204	.12	.12	−.03, .26	6.58		
Control group								
Dummy intervention	26	5,822	.09	.02	.02, .16	53.01***	.05	.83
No intervention	24	10,979	.08	.01	.02, .14	32.63		
Content of intervention								
General skills	5	306	.35[a]	.01	.10, .60	16.35**	4.71	.10
Eating habits/physical activity	19	7,508	.08[b]	.02	.01, .15	23. 61		
Mixed	26	8,987	.07[b]	.04	.00, .13	39.88*		
Mode of delivery[2]								
Interactive sessions	15	3,256	.18[a]	.00	.08, .27	43.28***	5.83	.02
Noninteractive materials	3	258	.26	.07	−.02, .53	6.61*		
Mixed	32	13,287	.05[b]	.09	−.01, .10	29.18		
Intervention provided to								
Parent only	10	1,928	.09	.14	−.03, .21	23.85**	.01	.92
Parent and child	40	14,873	.08	.00	.03, .13	61.71*		
Methodological quality								
Blinding								
Yes	22	6,068	.08	.04	.00, .15	42.73**	.19	.91
No	10	1,946	.07	.26	−.05, .19	21.03*		
NR	18	8,787	.10	.01	.02, .17	21.46		
Difference in baseline data								
Significant	4	1,217	.18	.02	.02, .34	11.11*	2.15	.34
Nonsignificant	37	11,026	.08	.00	.03, .14	59.57**		
NR	9	4,558	.04	.42	−.06, .14	12.97		

Effect sizes (ds) were calculated with one-tailed (unless specifically stated as two-tailed in the study) alpha set at .05. k = number of studies; N = total number of participants; CI = confidence interval; OB = obese; OW = overweight; NR = Not reported.
[a,b]Superscripts were used to denote the significant difference between subgroups. Same superscripts refer to a nonsignificant difference and different superscripts refer to a significant difference.
[1]BMI related outcomes refer to outcomes like BMI, zBMI, change in BMI and weight. The effect size for outcomes related to being obese/overweight (e.g., percentage of obese/overweight children) was .06 (95% CI = .01–.10, $p < .05$) at short-term follow-up.
[2]Contrasts were tested without subgroups of $k < 4$ studies.
*$p < .05$; **$p < .01$; ***$p < .001$.

Q = 77.56). This indicated that obesity interventions were effective at long-term follow-up but the combined effect did not survive adjustment for publication bias, suggesting the need for additional studies assessing follow-up effects. This is especially urgent because the number of studies with long-term follow-up assessments was restricted.

Moderators

We tested whether moderators regarding sample characteristics, study design, and methodological quality were related to the effect sizes for studies providing outcome at short-term (Table 4) and long-term (Table 5) follow-ups.

Table 5 Meta-analytic results of randomized interventions at long-term follow-up (k = 26 study outcomes)

	K	N	Cohen's d	p	95% CI	Q heterogeneity	Q Contrast	p Contrast
Total set	26	6,888	.09	.02	.01, .16	43.41*		
BMI-related outcomes only[1]	23	5,388	.12	.02	.02, .22	52.14***		
Sample characteristics								
Child age								
Before birth and Infancy	8	2,485	−.02	.77	−.16, .12	4.22	2.94	.09
Toddler/Preschool	18	4,403	.12	.01	.04, .21	32.90*		
Child baseline weight[2]								
OB and OW	3	133	.55	.00	.18, .92	5.88	.25	.62
Mixed	17	4,850	.05	.22	−03, .14	18.08		
Nonobese	0							
NR	6	1,905	.09	.18	−.05, .23	11.20*		
Parent baseline weight[2]								
OB and OW	1	16	1.68	.00	.52, 2.84	.00	.03	.86
Mixed	8	687	.09	.32	−.08, .26	3.69		
NR	17	6,185	.07	.07	−.01, .15	31.42*		
% Girls[2]								
≤20% girls	3	642	.13	.18	−.06, .32	.47	.59	.75
21%–79% girls	18	5,475	.06	.16	−.02, .14	29.46*		
≥80% girls	4	625	.03	.74	−.16, .22	3.54		
NR	1	146	.56	.01	.16, .96	.00		
% Minority in sample								
≤20% minority	6	550	.15	.15	−.06, .36	10.25	3.52	.32
21%–79% minority	4	480	.03	.77	−.18, .24	1.34		
≥80% minority	5	945	.20	.02	.04, .37	8.14		
NR	11	4,913	.04	.42	−.06, .13	15.66		
Continent								
North America	12	1,344	.20[a]	.00	.07, .33	17.57	5.24	.07
Europe	7	3,820	.01[b]	.88	−.10, .12	9.62		
Other	7	1,724	.06[a,b]	.35	−.06, .18	6.32		
Study design								
Duration of intervention[2]								
6 months or less	19	4,079	.10	.03	.01, .20	33.82*	.45	.50
7–12 months	5	2,385	.04	.63	−.12, .20	5.15		
13–24 months	2	424	.11	.41	−.15, .37	.74		
25 months or more	0							
NR	0							
Follow-up interval								
11 months or less	10	1,021	.13	.10	−.03, .28	17.94*	2.65	.27
12–36 months	9	2,260	.13	.02	.02, .24	14.11*		
37 months or more	7	3,607	.01	.99	−.12, .13	5.01		
Control group								
Dummy intervention	10	1,134	.17	.02	.01, .32	15.31	1.86	.17
No intervention	16	5,754	.05	.20	−.03, .14	23.50		
Content of intervention								
General skills	6	491	.31[a]	.00	.10, .52	17.96**	5.31	.07
Eating habits/physical activity	11	5,415	.04[b]	.34	−.04, .13	14.10		
Mixed	9	982	.08[a,b]	.28	−.07, .28	3.97		
Mode of delivery[2]								
Interactive sessions	9	3,689	.06	.32	−.06, .19	19.12*	.21	.65
Noninteractive materials	0							
Mixed	17	3,199	.10	.04	.01, .19	21.54*		
Intervention provided to								
Parent only	10	2,698	.01	.84	−.12, .14	6.58	1.73	.19
Parent and child	16	4,190	.12	.01	.03, .21	32.29**		

Table 5 (continued)

	K	N	Cohen's d	p	95% CI	Q heterogeneity	Q Contrast	p Contrast
Methodological quality								
Blinding								
Yes	15	3,690	.08	.10	−.02, .18	26.88*	1.30	.52
No	7	2,657	.05	.55	−.10, .19	8.33		
NR	4	541	.20	.07	−.02, .41	4.44		
Difference in baseline data								
Significant	6	2,282	.10	.15	−.04, .24	3.78	.57	.75
Nonsignificant	16	4,025	.07	.22	−.04, .17	27.14*		
NR	4	581	.15	.16	−.06, .36	10.06*		

Effect sizes (ds) were calculated with one-tailed (unless specifically stated as two-tailed in the study) alpha set at .05. k = fail-safe number of studies; n = total number of participants; CI, confidence interval; OB, obese; OW, overweight; IG, Intervention group; CG, control group; NR, not reported.
[a,b]Superscripts were used to denote the significant difference between subgroups. Same superscripts refer to a nonsignificant difference and different superscripts refer to a significant difference.
[1]BMI related outcomes refer to outcomes like BMI, zBMI, change in BMI and weight. The effect size for outcomes related to being obese/overweight (e.g., percentage of obese/overweight children) was .06 (95% CI = −.04–.17, $p > .05$) at long-term follow-up. After trim and fill, the adjusted effect size for the long-term follow-up results was .02, *ns* (95% CI = −.07–.11).
[2]Contrast was tested without subgroups of $k < 4$ studies.
$^*p < .05$; $^{**}p < .01$; $^{***}p < .001$.

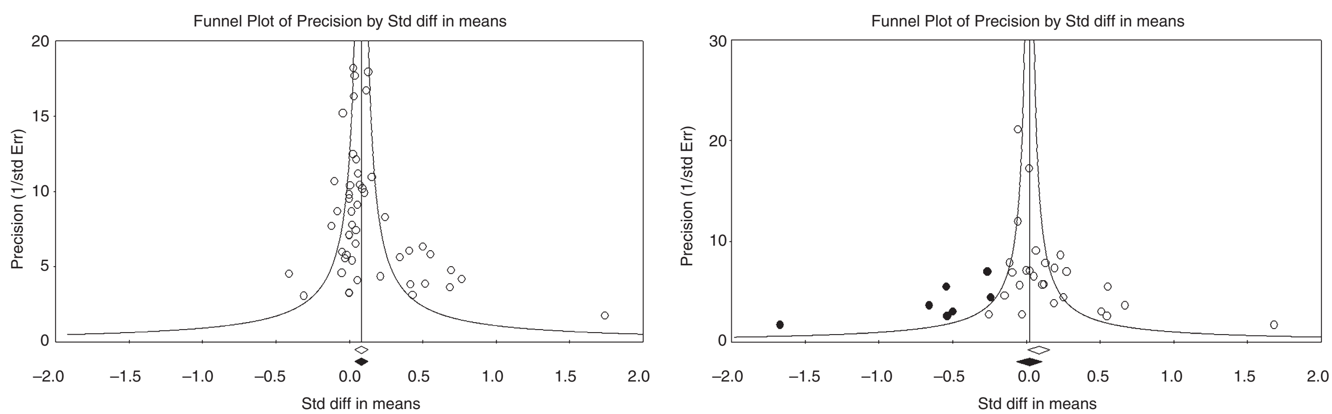

Figure 2 Funnel plots for short-term (at left) and long-term (at right) follow-up results. Filled black dots indicate number of studies filled. Filled black diamonds indicate the effect size after the trim and fill method

For outcomes at short-term follow-up, analyses revealed a significant effect of child baseline weight. Targeted interventions (i.e., with obese and overweight children; $d = .29$) were more effective than both universal interventions (i.e., interventions targeting both obese-overweight and nonobese, nonoverweight children; $d = .05$), and interventions that did not provide any information on child baseline weight ($d = .08$). Regarding the content of the intervention, the interventions targeting only general skills ($d = .35$) were also found to be more effective than interventions targeting eating habits/physical activity ($d = .08$), and mixed interventions ($d = .07$). Moreover, effect sizes were significantly higher for interventions in which the participants received only interactive sessions ($d = .18$) compared to when they received interactive sessions and educational materials ($d = .05$). None of the other moderators revealed significant effects at short-term follow-up.

Results for the long-term follow-up studies revealed a higher effect size for interventions targeting only general skills ($d = .31$) than interventions targeting only eating habits/physical activity ($d = .04$). Moreover, there was a significant difference between different regions, with interventions conducted in North America revealing a stronger effect ($d = .20$) than interventions conducted in Europe ($d = .01$) and other countries ($d = .06$). No other moderators yielded significant effects on intervention effectiveness at long-term follow-up.

With short-term follow-up results only, multivariate meta-regression analyses were also conducted to measure the relative effects of the moderators including child baseline obesity/overweight status, mode of intervention, and content of intervention. The analyses revealed that when these moderators were entered in the model, only the mode of intervention was significant, with results suggesting that interventions were more effective when interactive sessions or educational materials were used in the intervention as opposed to both interactive sessions and noninteractive educational materials ($\beta = -.10$, $p < .05$). No other moderator remained significant. This meta-regression outcome should, however, be interpreted with caution as several predictors had to be dummy-coded and were rather strongly associated. Small differences in predictive power might have led to the exclusion of some predictors that in a larger set of studies may have been included. Statistically, the power of meta-regression with categorical predictors is restricted, and replication is required.

As the interventions were not effective after the trim and fill method at long-term follow-up, and the set of studies even smaller than with the short-term follow-up studies multivariate analyses were not conducted for long-term follow-up results.

Discussion

The main aim of the current meta-analysis was to investigate the effectiveness of different types of obesity intervention programs targeted at young children and involving parents. Results revealed that the average effect size for the obesity interventions targeting young children and their parents were small (Cohen, 1988) but significant at short-term, yet nonsignificant at the long-term follow-up assessments. Multivariate meta-regression analyses showed that intervention programs with significantly higher effect sizes were the ones that provided the intervention in interactive sessions or in educational materials as opposed to both interactive sessions and educational materials.

Results showed that intervention programs were effective in obtaining changes in weight status of young children at short-term follow-up. Even though the effects were small and only 20% of the studies showed significant effect sizes, the combined effect size is robust. This is similar to the small effect sizes found in older children for obesity prevention (Stice et al., 2006), treating eating disorders (Stice & Shaw, 2004), and other health-related interventions like drug-use prevention (Tobler et al., 2000), indicating that high effect sizes in interventions are not easily achieved. Multiple meta-regression analysis revealed that interventions were more effective when participants received interactive sessions or educational materials than when they received both interactive sessions and educational materials. This is consistent with findings from other meta-analyses on interventions involving parents and children (e.g., Bakermans-Kranenburg et al., 2003; Stice et al., 2006). It may be that when parents receive more than one mode of intervention (i.e., both interactive sessions and educational materials), the information becomes too complex and diffused, and therefore less well received and understood as compared to information provided through only one mode of intervention. As hypothesized, demographic moderators including child age, gender, minority status, the continent that the data was obtained from, and the baseline weight status of the child and parents were not related to intervention effectiveness, suggesting that the findings can be generalized across different populations. Duration of the intervention, the content of the intervention, nor the target of the intervention were related to intervention effectiveness.

Even though the interventions were found to be effective at short-term follow-up, most of the studies providing results at long-term follow-up failed to show significant effects in changing child weight-related outcomes. Only five studies were effective at long-term follow-up (Bocca, Corpeleijn, Stolk, & Sauer, 2012; Brotman et al., 2012; Fitzgibbon et al., 2005; Nemet et al., 2013; Stark et al., 2011), all of which were initiated during the preschool years rather than in infancy. Moreover, three of these five studies with the highest effect sizes at long-term follow-up included an additional general parenting skills and behaviors component (Bocca et al., 2012; Brotman et al., 2012; Stark et al., 2011). Further, the study with the highest effect size at long-term follow-up (Stark et al., 2011) applied booster maintenance sessions after the end of the more intensive intervention sessions. It is possible that having booster sessions after the end of the intervention increases or maintains intervention effectiveness in the longer term by making the information better understood and reflected upon without decreasing participant motivation with prolonged sessions (Eyberg, Edwards, Boggs, & Foote, 1998; Nation et al., 2003). Interestingly, among the interventions included in the meta-analysis, only three studies were found to be effective both at short-term and long-term follow-ups (Bocca et al., 2012; Nemet, Geva, Pantanowitz, et al., 2011; Nemet et al., 2013; Stark et al., 2011), each of which targeted preschool children. Two of these three studies were conducted with children who were obese or overweight, and focused on general parenting skills in interactive sessions. Finally, the results of the long-term follow-up studies suggested that targeting general parenting skills and behaviors was one of the very few factors positively related to intervention effectiveness. However, because of the nonsignificant mean effect sizes after correcting for publication bias, more intervention studies with long-term follow-up results are necessary to draw firm conclusions.

Obesity is a growing public health concern with high economical costs both to the individual and to the society. In a recent review, obesity was estimated to account for about 0.7%–2.8% of a society's health care expenditures, with the estimated costs ranging from \$3.6 million to \$78.5 billion per country, across the world (Withrow & Alter, 2010). Indeed, a cost-effectiveness study found that making large investments in prevention and treatment programs for 6-, 12- and 19-year-old children with obesity/overweight seems cost-effective by widely accepted criteria (Trasande, 2010). Moreover, intervening even earlier in life, as was done by the studies included in this meta-analysis, is usually found to have much higher returns than later interventions (Heckman, 2006). As such, although the cost-effectiveness of early interventions (like the ones included in this meta-analysis) has not been investigated (Bond et al., 2009), prevention and treatment programs that focus on the first years of life are expected to be even more cost-effective.

Importantly, the current meta-analysis suggests that programs using one mode of intervention (rather than multiple modes) were more effective, which is also relevant to cost-effectiveness because fewer resources may be required for single-mode interventions. Although the overall effect size was small, the current meta-analysis does provide the important insight that at very young ages, interventions can impose positive changes in obesity development. In addition, some of the interventions that did not find significant differences in weight-related outcomes, did find significant effects in outcomes indicating a healthier lifestyle that may precede weight loss, such as increased fruit and vegetable consumption (Bayer et al., 2009 sample 2; Crespo et al., 2012; De Bock et al., 2012; Warren, Henry, Lightowler, Bradshaw, & Perwaiz, 2003; Zask, Adams, Brooks, & Hughes, 2012), increased physical skills (Bellows et al., 2013; Puder et al., 2011; Zask et al., 2012), improved child knowledge, attitude, and habits toward diet and physical activity (Cespedes et al., 2013; Nemet, Geva, and Eliakim, 2011; Warren et al., 2003), as well as decreased sedentary behaviors (Campbell et al., 2013; Dennison, Russo, Burdick, & Jenkins, 2004; Epstein et al., 2008; Taveras et al., 2011), consumption of energy-dense foods (Harvey-Berino & Rourke, 2003; Louzada, Campagnolo, Rauber, & Vitolo, 2012) and sugar-sweetened beverages (Story et al., 2012). Moreover, McCartney and Rosenthal (2000) warn that small effect sizes in social sciences are to be expected, generally because of methodological limitations in complex areas of research, and should not be dismissed quickly. Using an example of an experiment suggesting the use of aspirin to reduce (second) heart attacks based on a small effect size (r = .03), they argued that even small effect sizes may have very large policy implications, specifically in health-related matters that might influence a large number of individuals across the life span. Hence, small changes may be cost-effective and can impose large economic gains, especially in the long term, considering the physical and psychological gains that would be obtained from effective obesity interventions (Reilly & Kelly, 2011; Schwartz & Puhl, 2003). Early childhood (preschool and before) should therefore be considered an important time for cost-effective obesity interventions.

Some limitations of the study should be noted. First of all, the studies were highly diverse in nature and even the large set of moderators that we included did not split the data into homogenous subsets. Nevertheless, our analyses do provide clues about aspects of early interventions involving parents that might be related to increased effectiveness. Using combinations of moderators may lead to more homogenous subsets of studies, but in the current meta-analysis, the combination of moderators was not always possible because of the small subsets of studies when moderators were combined, and those that did yield sufficient subset sizes did not add new information to the current results and were therefore not presented. Another limitation was the relative scarcity of studies providing sufficient details about the intervention design or presenting results in adequate detail, despite the focus of the current meta-analysis on randomized controlled trials only. Finally, some moderators were closely associated with each other. For instance, although conceptually distinct, the content of the intervention and mode of delivery of the intervention partially overlapped, with interventions focusing on general skills being more likely to be conducted in interactive sessions (or mixed) in 4 out of 5 studies. However, the other categories of these moderators did provide unique information.

This meta-analysis has various implications for future research. First, more long-term follow-up studies of interventions targeting young children should be conducted to better understand the moderators that are linked to increased sustainability of their effects. Second, gene–environment interactions may be worthwhile to study in this field, as differential susceptibility depending on individuals' genetic characteristics is particularly relevant for interventions (Van IJzendoorn & Bakermans-Kranenburg, 2012). For instance, a sub-group of susceptible children, for example, characterized by dopamine receptor gene DRD4 7-repeat alleles (Bakermans-Kranenburg & Van IJzendoorn, 2011), may profit more from the positive environment created by obesity interventions and the overall small effect size might reflect an underestimation of the effect for that specific group. Future studies may thus investigate the role of gene-by-intervention interactions and the possibility of differential susceptibility.

In conclusion, obesity is an expanding health problem which requires urgent attention starting from very young ages. The results of this meta-analytic study shows that interventions targeting parents who have children at preschool age or younger were effective specifically when interventions were conducted with one mode of intervention rather than using two modes. However, more studies are required to understand factors associated with the maintenance of the obesity intervention effects in the long run.

Acknowledgements

This work was supported by a grant from the Leiden University research profile area: health, prevention and the human life cycle. The authors have declared that they have no competing or potential conflicts of interests.

Correspondence

Judi Mesman, Centre for Child and Family Studies, Leiden University, P.O. Box 9555, Leiden 2300 RB, The Netherlands; Email: mesmanj@fsw.leidenuniv.nl

Key points

- Childhood obesity is a major health concern starting from a very early age, with high costs for society and the individual.
- Early childhood obesity interventions were previously shown to be more effective with parental involvement, yet the features of programs with parental involvement related to intervention effectiveness in very young children have not been investigated.
- This meta-analysis showed that interventions targeting young children and requiring parental involvement were effective in the short, but not in the longer term.
- More focused interventions were more effective than those including multiple modes of intervention.
- Future studies are needed to determine the factors associated with the maintenance of intervention effects in the long run.

References

References marked with an asterisk were included in the meta-analysis

Bakermans-Kranenburg, M.J., & Van IJzendoorn, M.H. (2011). Differential susceptibility to rearing environment depending on dopamine-related genes: New evidence and a meta-analysis. *Development and Psychopathology*, *23*, 39–52.

Bakermans-Kranenburg, M.J., Van IJzendoorn, M. H., & Juffer, F. (2003). Less is more: Meta-analyses of sensitivity and attachment interventions in early childhood. *Psychological Bulletin*, *129*, 195–215.

Bakermans-Kranenburg, M.J., Van IJzendoorn, M.H., & Juffer, F. (2005). Disorganized infant attachment and preventive interventions: A review and meta-analysis. *Infant Mental Health Journal*, *26*, 191–216.

*Barkin, S.L., Gesell, S.B., Po'e, E.K., Escarfuller, J., & Tempesti, T. (2012). Culturally tailored, family-centered, behavioral obesity intervention for Latino-American preschool-aged children. *Pediatrics*, *130*, 445–456.

*Bayer, O., von Kries, R., Strauss, A., Mitschek, C., Toschke, A.M., Hose, A., & Koletzko, B.V. (2009). Short- and mid-term effects of a setting based prevention program to reduce obesity risk factors in children: a cluster-randomized trial. *Clinical Nutrition*, *28*, 122–128.

*Bellows, L.L., Davies, P.L., Anderson, J., & Kennedy, C. (2013). Effectiveness of a physical activity intervention for head start preschoolers: A randomized intervention study. *American Journal of Occupational Therapy*, *67*, 28–36.

*Berry, D., Colindres, M., Sanchez-Lugo, L., Sanchez, M., Neal, M., & Smith-Miller, C. (2011). Adapting, feasibility testing, and pilot testing a weight management intervention for recently immigrated Spanish-speaking women and their 2- to 4-year-old children. *Hispanic Health Care International*, *9*, 186–193.

Birch, L.L., & Ventura, A.K. (2009). Preventing childhood obesity: What works? *International Journal of Obesity*, *33*, s74–81.

*Birken, C.S., Maguire, J., Mekky, M., Manlhiot, C., Beck, C.E., DeGroot, J., ... & Parkin, P.C. (2012). Office-based randomized controlled trial to reduce screen time in preschool children. *Pediatrics*, *130*, 1110–1115.

*Bocca, G., Corpeleijn, E., Stolk, R.P., & Sauer, P.J.J. (2012). Results of a multidisciplinary treatment program in 3-year-old to 5-year-old overweight or obese children a randomized controlled clinical trial. *Archives of Pediatrics & Adolescent Medicine*, *166*, 1109–1115.

Bond, M., Wyatt, K., Lloyd, J., Welch, K., & Taylor, R. (2009). Systematic review of the effectiveness and cost-effectiveness of weight management schemes for the under fives: A short report. *Health Technology Assessment*, *13*, 1–75.

Borenstein, M., Hedges, L., & Rothstein, H. (2007). Meta-analysis: Fixed effect vs. random effects. Retrieved from http://www.metaanalysis.com/downloads/Metaanalysis%20fixed%20effect%20vs%20random%20effects%20(pre%20tags).pdf

Borenstein, M., Rothstein, D., & Cohen, J. (2005). *Comprehensive meta-analysis: A computer program for research synthesis*. Englewood, NJ: Biostat.

*Brotman, L.M., Dawson-McClure, S., Huang, K.Y., Theise, R., Kamboukos, D., Wang, J., & Ogedegbe, G. (2012). Early childhood family intervention and long-term obesity prevention among high-risk minority youth. *Pediatrics*, *129*, e621–628.

Campbell, K.J., & Hesketh, K.D. (2007). Strategies which aim to positively impact on weight, physical activity, diet and sedentary behaviours in children from zero to five years. A systematic review of the literature. *Obesity Reviews*, *8*, 327–338.

*Campbell, K.J., Lioret, S., McNaughton, S.A., Crawford, D.A., Salmon, J., Ball, K., & Hesketh, K.D. (2013). A parent-focused intervention to reduce infant obesity risk behaviors: A randomized trial. *Pediatrics*, *131*, 652–660.

Certain, L.K., & Kahn, R.S. (2002). Prevalence, correlates, and trajectory of television viewing among infants and toddlers. *Pediatrics*, *109*, 634–642.

*Cespedes, J., Briceno, G., Farkouh, M.E., Vedanthan, R., Baxter, J., Leal, M., & Fuster, V. (2013). Targeting preschool children to promote cardiovascular health: Cluster randomized trial. *American Journal of Medicine*, *126*, 27–35.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd edn). Hillsdale, NJ: Erlbaum.
*Crespo, N.C., Elder, J.P., Ayala, G.X., Slymen, D.J., Campbell, N.R., Sallis, J.F., & Arredondo, E.M. (2012). Results of a multi-level intervention to prevent and control childhood obesity among Latino children: the Aventuras Para Ninos Study. *Annals of Behavioral Medicine*, *43*, 84–100.
*De Bock, F., Breitenstein, L., & Fischer, J.E. (2012). Positive impact of a pre-school-based nutritional intervention on children's fruit and vegetable intake: results of a cluster-randomized trial. *Public Health Nutrition*, *15*, 466–475.
*De Coen, V., De Bourdeaudhuij, I., Vereecken, C., Verbestel, V., Haerens, L., Huybrechts, I., & Maes, L. (2012). Effects of a 2-year healthy eating and physical activity intervention for 3-6-year-olds in communities of high and low socio-economic status: the POP (Prevention of Overweight among Pre-school and school children) project. *Public Health Nutrition*, *15*, 1737–1745.
*Dennison, B.A., Russo, T.J., Burdick, P.A., & Jenkins, P.L. (2004). An intervention to reduce television viewing by preschool children. *Archives of Pediatrics & Adolescent Medicine*, *158*, 170–176.
Duval, S., & Tweedie, R. (2000a). A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *Journal of the American Statistical Association*, *95*, 89–98.
Duval, S., & Tweedie, R. (2000b). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*, 455–463.
*Epstein, L.H., Roemmich, J.N., Robinson, J.L., Paluch, R.A., Winiewicz, D.D., Fuerch, J.H., & Robinson, T.N. (2008). A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Archives of Pediatrics & Adolescent Medicine*, *162*, 239–245.
Eschenbeck, H., Kohlmann, C., Dudey, S., & Schürholz, T. (2009). Physician-diagnosed obesity in German 6-to-14-year-olds. *Obesity Facts*, *2*, 67–73.
Eyberg, S.M., Edwards, D., Boggs, S.R., & Foote, R. (1998). Maintaining the treatment effects of parent training: The role of booster sessions and other maintenance strategies. *Clinical Psychology: Science and Practice*, *5*, 544–554.
Faith, M.S., van Horn, L., Appel, L.J., Burke, L.E., Carson, J.A., Franch, H.A., ... & Wylie-Rosett, J. (2012). Evaluating parent and adult caregivers as "Agents of Change" for treating obese children: Evidence for parent behavior change strategies and research gaps: A scientific statement from the American Heart Association. *Circulation*, *125*, 1186–1207.
Finkelstein, E.A., Ruhm, C.J., & Kosa, K.M. (2005). Economic causes and consequences of obesity. *Annual Review of Public Health*, *26*, 239–57.
*Fitzgibbon, M.L., Stolley, M.R., Schiffer, L.A., Braunschweig, C.L., Gomez, S.L., Van Horn, L., & Dyer, A.R. (2011). Hip-hop to health Jr. obesity prevention effectiveness trial: Postintervention results. *Obesity (Silver Spring)*, *19*, 994–1003.
*Fitzgibbon, M.L., Stolley, M.R., Schiffer, L., Kong, A., Braunschweig, C.L., Gomez-Perez, S.L., ... & Dyer, A.R. (2013). Family-based hip-hop to health: outcome results. *Obesity (Silver Spring)*, *21*, 274–283.
*Fitzgibbon, M.L., Stolley, M., Schiffer, L., Van Horn, L., KauferChristoffel, K., & Dyer, A. (2005). Two-year follow-up results for hip-hop to health Jr.: A randomized controlled trial for overweight prevention in preschool minority children. *Journal of Pediatrics*, *146*, 618–625.
*Fitzgibbon, M.L., Stolley, M.R., Schiffer, L., Van Horn, L., KauferChristoffel, K., & Dyer, A. (2006). Hip-hop to health Jr. for Latino preschool children. *Obesity (Silver Spring)*, *14*, 1616–1625.
Fox, M.K., Reidy, K., Novak, T., & Ziegler, P. (2006). Sources of energy and nutrients in the diets of infants and toddlers. *Journal of American Dietetic Association*, *106*, S28–42.
*French, G.M., Nicholson, L., Skybo, T., Klein, E.G., Schwirian, P.M., Murray-Johnson, L., ... & Groner, J.A. (2012). An evaluation of mother-centered anticipatory guidance to reduce obesogenic infant feeding behaviors. *Pediatrics*, *130*, e507–517.
Gerards, S., Sleddens, E., Dagnelie, P., de Vries, N., & Kremers, S. (2011). Interventions addressing general parenting to prevent or treat childhood obesity. *International Journal of Pediatric Obesity*, *6*, e28–45.
Gilbody, S.M., Song, F.J., Eastwood, A.J., & Sutton, A. (2000). The causes, consequences and detection of publication bias in psychiatry. *Acta Psychiatrica Scandinavica*, *102*, 241–249.
*Hakanen, M., Lagstrom, H., Kaitosaari, T., Niinikoski, H., Nanto-Salonen, K., Jokinen, E., ... & Simell, O. (2006). Development of overweight in an atherosclerosis prevention trial starting in early childhood. The STRIP study. *International Journal of Obesity*, *30*, 618–626.
Halfon, N., Larson, K., & Slusser, W. (2013). Associations between obesity and comorbid mental health, developmental and physical health conditions in a nationally representative sample of US children aged 10 to 17. *Academic Pediatrics*, *13*, 6–13.
Harrist, A.W., Topham, G.L., Hubbs-Tait, L., Page, M., Kennedy, T.S., & Shriver, L.H. (2012). What developmental science can contribute to a transdisciplinary understanding of childhood obesity: an interpersonal and intrapersonal risk model. *Child Development Perspectives*, *6*, 445–455.
*Harvey-Berino, J., & Rourke, J. (2003). Obesity prevention in preschool native-american children: a pilot study using home visiting. *Obesity Research*, *11*, 606–611.
Heckman, J.J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, *312*, 1900–1902.
Hesketh, K.D., & Campbell, K.J. (2010). Interventions to prevent obesity in 0–5 year olds: An updated systematic review of the literature. *Childhood Obesity*, *18*, s27–35.
Hingle, M.D., O'Connor, T.M., Dave, J.M., & Baranowski, T. (2010). Parental involvement in interventions to improve child dietary intake: A systematic review. *Preventive Medicine*, *51*, 103–111.
Hollingworth, W., Hawkins, J., Lawlor, D.A., Brown, M., Marsh, T., & Kipping, R.R. (2012). Economic evaluation of lifestyle interventions to treat overweight or obesity in children. *International Journal of Obesity*, *36*, 559–566.
Jeor, S., Perumean-Chaney, S., Sigman-Grant, M., Williams, C., & Foreyt, J. (2002). Family-based interventions for the treatment of childhood obesity. *Journal of the American Dietetic Association*, *102*, 640–644.
*Jouret, B., Ahluwalia, N., Dupuy, M., Cristini, C., Nègre-Pages, L., Grandjean, H., & Tauber, M. (2009). Prevention of overweight in preschool children: Results of kindergarten-based interventions. *International Journal of Obesity*, *33*, 1075–1083.
*Karanja, N., Lutz, T., Ritenbaugh, C., Maupome, G., Jones, J., Becker, T., & Aickin, M. (2010). The TOTS community intervention to prevent overweight in American Indian toddlers beginning at birth: a feasibility and efficacy study. *Journal of Community Health*, *35*, 667–675.
*Kavanagh, K.F., Cohen, R.J., Heinig, M.J., & Dewey, K.G. (2008). Educational intervention to modify bottle-feeding behaviors among formula-feeding mothers in the WIC program: Impact on infant formula intake and weight gain. *Journal of Nutrition Education and Behavior*, *40*, 244–250.
Kitzman, K.M., Dalton, W., Stanley, C., Beech, B., Reeves, T., Buscemi, J., , ... & Midgett, E. (2010). Lifestyle interventions

for youth who are overweight: A meta-analytic review. *Health Psychology*, *29*, 91–101.

Lindsay, A.C., Sussner, K.M., Kim, J., & Gortmaker, S. (2006). The role of parents in preventing childhood obesity. *The Future of Children*, *16*, 169–186.

Lipsey, M.W., & Wilson, D.B. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage.

*Llargues, E., Franco, R., Recasens, A., Nadal, A., Vila, M., Pérez, M.J., ... & Castells, C. (2011). Assessment of a school-based intervention in eating habits and physical activity in school children: the AVall study. *Journal of Epidemiology & Community Health*, *65*, 896–901.

*Llargues, E., Recasens, A., Franco, R., Nadal, A., Vila, M., Pérez, M.J., ... & Castell, C. (2012). Medium-term evaluation of an educational intervention on dietary and physical exercise habits in schoolchildren: The AVall 2 study. *Endocrinologia y Nutricion*, *59*, 288–295.

*Louzada, M.L.D., Campagnolo, P.D., Rauber, F., & Vitolo, M.R. (2012). Long-term effectiveness of maternal dietary counseling in a low-income population: A randomized field trial. *Pediatrics*, *129*, E1477–E1484.

Lumeng, J., Forrest, P., Appugliese, D., Kaciroti, N., Corwyn, R., & Bradley, R. (2010). Weight status as a predictor of being bullied in third through sixth grades. *Pediatrics*, *125*, e1301–e1307.

Maes, H.M., Neale, M.C., & Eaves, L. (1997). Genetic and environmental factors in relative body weight and human adiposity. *Behavior Genetics*, *27*, 325–351.

Magarey, A.M., Daniels, L.A., Boulton, T.J., & Cockington, R.A. (2003). Predicting obesity in early adulthood from childhood and parental obesity. *International Journal of Obesity*, *27*, 505–513.

*Martin, R.M., Patel, R., Kramer, M. S., Guthrie, L., Vilchuck, K., Bogdanovich, N., ... & Oken, E. (2013). Effects of promoting longer-term and exclusive breastfeeding on adiposity and insulin-like growth factor-I at age 11.5 years: a randomized trial. *JAMA*, *309*, 1005–1013.

McCartney, K., & Rosenthal, R. (2000). Effect size, practical importance, and social policy for children. *Child Development*, *71*, 173–180.

Mullen, B. (1989). *Advanced basic meta-analysis*. Hillsdale, NJ: Erlbaum.

Nation, M., Crusto, C., Wandersman, A., Kumpfer, K.L., Seybolt, D., Morrissey-Kane, E., & Davino, K. (2003). What works in prevention: Principles of effective prevention programs. *American Psychologist*, *58*, 449–456.

*Nemet, D., Geva, D., & Eliakim, A. (2011). Health promotion intervention in low socioeconomic kindergarten children. *Journal of Pediatrics*, *158*, 796–801 e791.

*Nemet, D., Geva, D., Pantanowitz, M., Igbaria, N., Meckel, Y., & Eliakim, A. (2011). Health promotion intervention in Arab-Israeli kindergarten children. *Journal of Pediatric Endocrinology & Metabolism*, *24*, 1001–1013.

*Nemet, D., Geva, D., Pantanowitz, M., Igbaria, N., Meckel, Y., & Eliakim, A. (2013). Long term effects of a health promotion intervention in low socioeconomic Arab- Israeli kindergartens. *BMC Pediatrics*, *13*, 45.

Niemeier, B.S., Hektner, J.M., & Enger, K.B. (2012). Parent participation in weight-related health interventions for children and adolescents: A systematic review and meta-analysis. *Preventive Medicine*, *55*, 3–13.

*Østbye, T., Krause, K.M., Stroo, M., Lovelady, C.A., Evenson, K.R., Peterson, B.L., ... & Zucker, N.L. (2012). Parent-focused change to prevent obesity in preschoolers: Results from the KAN-DO study. *Preventive Medicine: An International Journal Devoted to Practice and Theory*, *55*, 188–195.

*Paul, I.M., Savage, J.S., Anzman, S.L., Beiler, J.S., Marini, M.E., Stokes, J.L., & Birch, L.L. (2011). Preventing obesity during infancy: A pilot study. *Obesity (Silver Spring)*, *19*, 353–361.

*Plachta-Danielzik, S., Landsberg, B., Lange, D., Seiberl, J., & Muller, M.J. (2011). Eight-year follow-up of school-based intervention on childhood overweight - the Kiel obesity prevention study. *Obesity Facts*, *4*, 35–43.

*Puder, J., Marques-Vidal, P., Schindler, C., Zahner, L., Niederer, I., Bürgi, F., ... & Kriemler, S. (2011). Effect of multidimensional lifestyle intervention on fitness and adiposity in predominantly migrant preschool children (Ballabeina): cluster randomised controlled trial. *British Medical Journal*, *343*, 945–945.

*Quattrin, T., Roemmich, J.N., Paluch, R., Yu, J., Epstein, L.H., & Ecker, M.A. (2012). Efficacy of family-based weight control program for preschool children in primary care. *Pediatrics*, *130*, 660–666.

Reilly, J.J., & Kelly, J. (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: Systematic review. *International Journal of Obesity*, *35*, 891–898.

*Reilly, J.J., Kelly, L., Montgomery, C., Williamson, A., Fisher, A., McColl, J.H., ... & Grant, S. (2006). Physical activity to prevent obesity in young children: cluster randomised controlled trial. *British Medical Journal*, *333*, 1041–1045.

Reilly, J.J., Methven, E., McDowell, Z.C., Hacking, B., Alexander, D., Stewart, L., & Kelnar, C.J.H. (2003). *Archives of Disease in Childhood*, *88*, 748–752.

Rosenthal, R. (1995). Writing meta-analytic reviews. *Psychological Bulletin*, *118*, 183–192.

*Rush, E., Reed, P., McLennan, S., Coppinger, T., Simmons, D., & Graham, D. (2012). A school-based obesity control programme: Project energize. Two-year outcomes. *British Journal of Nutrition*, *107*, 581–587.

*Scheiwe, A., Hardy, R., & Watt, R.G. (2010). Four-year follow-up of a randomized controlled trial of a social support intervention on infant feeding practices. *Maternal and Child Nutrition*, *6*, 328–337.

Schwartz, M.B., & Puhl, R. (2003). Childhood obesity: A societal problem to solve. *Obesity Reviews*, *4*, 57–71.

*Slusser, W., Frankel, F., Robison, K., Fischer, H., Cumberland, W.G., & Neumann, C. (2012). Pediatric overweight prevention through a parent training program for 2-4 year old Latino children. *Childhood Obesity*, *8*, 52–59.

*Small, L., Bonds-McClain, D., Melnyk, B., Vaughan, L., & Gannon, A.M. (2013). The preliminary effects of a primary care-based randomized treatment trial with overweight and obese young children and their parents. *Journal of Pediatric Health Care*, *28*, 198–207.

Snyder, E.E., Walts, B., Perusse, L., Chagnon, Y.C., Weisnagel, J., Rankinen, T., & Bouchard, C. (2004). The human obesity gene map: The 2003 update. *Obesity Research*, *12*, 369–439.

Speiser, P., Rudolf, M., Anhalt, H., Camacho-Hubner, C., Chiarelli, F., Eliakim, A. ... & Hochberg, Z. (2005). Consensus statement: Childhood obesity. *The Journal of Clinical Endocrinology & Metabolism*, *90*, 1871–1887.

*Stark, L.J., Spear, S., Boles, R., Kuhl, E., Ratcliff, M., Scharf, C., ... & Rausch, J. (2011). A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers. *Obesity (Silver Spring)*, *19*, 134–141.

Stice, E., & Shaw, H. (2004). Eating disorder prevention programs: A meta-analytic review. *Psychological Bulletin*, *130*, 206–227.

Stice, E., Shaw, H., & Marti, C.N. (2006). A meta-analytic review of obesity prevention programs for children and adolescents: The skinny on interventions that work. *Psychological Bulletin*, *132*, 667–691.

*Story, M., Hannan, P.J., Fulkerson, J.A., Rock, B.H., Smyth, M., Arcan, C., & Himes, J.H. (2012). Bright Start: Description and main outcomes from a group-randomized obesity prevention trial in American Indian children. *Obesity*, *20*, 2241–2249.

Sung-Chan, P., Sung, Y.W., Zhao, X., & Brownson, R. (2013). Family-based models for childhood-obesity intervention:

A systematic review of randomized controlled trials. *Obesity Reviews*, *14*, 265–278.
Sutton, A.J., Duval, S.J., Tweedie, R.L., Abrams, K.R., & Jones, D.R. (2000). Empirical assessment of effect of publication bias on meta-analyses. *British Medical Journal*, *320*, 1574–1577.
*Taveras, E.M., Gortmaker, S.L., Hohman, K.H., Horan, C.M., Kleinman, K.P., Mitchell, K., ... & Gillman, M.W. (2011). Randomized controlled trial to improve primary care to prevent and manage childhood obesity: the High Five for Kids study. *Archives of Pediatrics & Adolescent Medicine*, *165*, 714–722.
Tobler, N.S., Roona, M.R., Ochshorn, P., Marshall, D.G., Streke, A.V., & Stackpole, K.M. (2000). School-based adolescent drug prevention programs: 1998 meta-analysis. *Journal of Primary Prevention*, *20*, 275–336.
Trasande, L. (2010). How much should we invest in preventing childhood obesity? *Health Affairs*, *29*, 372–378.
Van IJzendoorn, M.H., & Bakermans-Kranenburg, M.J. (2012). Differential susceptibility experiments: Going beyond correlational evidence: Comment on beyond mental healtu, differential susceptibility articles. *Developmental Psychology*, *48*, 769–774.
*Verbestel, V., De Coen, V., Van Winckel, M., Huybrechts, I., Maes, L., & De Bourdeaudhuij, I. (2014). Prevention of overweight in children younger than 2 years old: a pilot cluster-randomized controlled trial. *Public Health Nutrition*, *17*, 1384–1392.
*Wake, M., Price, A., Clifford, S., Ukoumunne, O.C., & Hiscock, H. (2011). Does an intervention that improves infant sleep also improve overweight at age 6? Follow-up of a randomised trial. *Archives of Disease in Childhood*, *96*, 526–532.
Wang, Y., & Lobstein, T. (2006). Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity*, *1*, 11–25.
*Warren, J.M., Henry, C.J.K., Lightowler, H.J., Bradshaw, S.M., & Perwaiz, S. (2003). Evaluation of a pilot school programme aimed at the prevention of obesity in children. *Health Promotion International*, *18*, 287–296.
Warschburger, P. (2005). The unhappy obese child. *International Journal of Obesity*, *29*, 127–129.
Waters, E., de Silva-Sanigorski, A., Hall, B.J., Brown, T., Campbell, K.J., Gao, Y., ... & Summerbell, C.D. (2011). Interventions for preventing obesity in children (Review). *The Cochrane Library*, *12*, doi:10.1002/14651858.CD001871.pub3.
Weinsier, R., Hunter, G., Heini, A., Goran, M., & Sell, S. (1998). The efiology of obesity: Relative contribution of metabolic factors, diet, and physical activity. *American Journal of Medicine*, *105*, 145–150.
*Wen, L.M., Baur, L.A., Simpson, J.M., Rissel, C., Wardle, K., & Flood, V.M. (2012). Effectiveness of home based early intervention on children's BMI at age 2: randomised controlled trial. *British Medical Journal*, *344*, e3732.
Wilfley, D.E., Stein, R.I., Saelens, B.E., Mockus, D.S., Matt, G.E., Hayden-Wade, H.A., ... & Epstein, L.H. (2007). Efficacy of maintenance treatment approaches for childhood overweight A randomized controlled trial. *Journal of the American Medical Association*, *298*, 1661–1673.
Withrow, D., & Alter, D. (2010). The economic burden of obesity world-wide: A systematic review of the direct costs of obesity. *Obesity Review*, *12*, 131–141.
Xie, B., Ishibashi, K., Lin, C., Peterson, D., & Susman, E. (2013). Overweight trajectories and psychosocial adjustment among adolescents. *Preventive Medicine*, *57*, 837–843.
Young, K.M., Northern, J., Lister, K.M., Drummond, J.A., & O'Brien, W. (2007). A meta-analysis of family-behavioral weight-loss treatments for children. *Clinical Psychology Review*, *27*, 240–249.
*Zask, A., Adams, J.K., Brooks, L.O., & Hughes, D.F. (2012). Tooty Fruity Vegie: an obesity prevention intervention evaluation in Australian preschools. *Health Promotion Journal of Australia*, *23*, 10–15.

Accepted for publication: 14 August 2014