

Treatment of Childhood Obesity: A Systematic Review

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Abstract Childhood obesity trends have increased dramatically over the past three decade's. The purpose of this quantitative systematic review is to provide an update of the evidence, illustrating the efficacy of childhood obesity treatment, considering whether treatment fidelity has been measured and/or reported and whether this related to the treatment effect size. Searches revealed 61 relevant articles published from January 2000 to 2009, including both randomized and non-randomized controlled trials of childhood and adolescent obesity treatment interventions. The review identified scant measurement and reporting of issues around treatment fidelity, an increase in the number of interventions outside of the US, (particularly across Europe) and an emergence of studies involving older children and adolescents in a range of settings. Interventions comprising a dietary, exercise, and behavioral component, supported by family involvement and delivered by trained interventionists in specialized or supervised settings, appeared to offer a potentially effective treatment for obesity. However, concern remains over study quality (particularly sample size), dropout rates and study design. Variations in outcome measures and intervention designs means generalizable conclusions cannot be easily be made. Of greater concern is the lack of consideration for treatment fidelity, which has implications for the transfer of knowledge and the reliability of interventions. Conclusions from the review include; the need for increased accuracy of reporting and objective measurement of treatment fidelity; the need for further investigation of potential cost-effective treatment options (including maintenance strategies to

enhance sustainability of current interventions); and an increase in the number of longitudinal trials beyond 1 year in duration.

Keywords Child/Adolescent · Overweight/Obesity · Treatment

Introduction

The past three decades have seen a dramatic global increase in childhood/adolescent obesity (Jelalian et al. 2007). Review estimates of childhood overweight and obesity range from 12 to 30% in developed countries and from 2 to 12% in developing countries (Lobstein et al. 2004). Obesity is a multifaceted, complex disease (Borra et al. 2003) associated with numerous negative medical complications (Wabitsch 2000) and psychosocial consequences (Faith et al. 2001). Furthermore, if obesity persists into adulthood it carries an increased risk of earlier morbidity and mortality (Must and Strauss 1999). To avoid serious health consequences later in life, we need to address this high incidence of obesity.

Childhood Obesity Treatment Recommendations

Previous reviews have suggested that multifaceted lifestyle interventions that focus on dietary change, physical activity (PA) promotion, and include a behavioral component (e.g. stimulus control) are the best available option for treatment (Caprio 2006; Collins et al. 2006; Flynn et al. 2006; Jelalian et al. 2007; Luitikhuis et al. 2009; Snethen et al. 2006; Steinbeck 2005; Summerbell et al. 2003). Moreover, family involvement has been acknowledged as a key feature of effective interventions and expert recommendations

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suggest that multifaceted interventions should be delivered by a multidisciplinary team with expert training in the relevant area of intervention and that the intensity of treatment depends on the degree of obesity and the child's age (Barlow 2007; Luutikhuis et al. 2009).

Childhood Obesity Treatment Limitations

Previous reviews have suggested that inconsistencies exist around study design, study quality and outcome measures; small sample sizes; and infrequent measurement of compliance/adherence to lifestyle advice (Snethen et al. 2006; Summerbell et al. 2003). Few interventions have been implemented outside of specialized settings with diverse study samples limiting the generalizability of findings (Flynn et al. 2006; Summerbell et al. 2003). Despite inclusion of a further 36 studies, the most recent Cochrane review drew similar conclusions, suggesting family based, behavioral interventions that target PA and diet appear to be effective (Luutikhuis et al. 2009). While noting the value of other reviews of childhood obesity treatment interventions, these have focused on treatment effectiveness solely based on primary and/or secondary outcome measures (e.g. BMI, behavior change, and psychosocial measures) and ignored issues around treatment fidelity (i.e. was the intervention delivered as intended and reported).

Treatment Fidelity

Treatment fidelity refers to the methodological strategies used to monitor and enhance the reliability and validity of behavioral interventions and is acknowledged as an integral part of the conduct and evaluation of all health behavioral intervention research (Bellg et al. 2004). Treatment fidelity covers study design, provider training, treatment delivery, treatment receipt, and enactment of treatment skills (Bellg et al. 2004; Breckon et al. 2008) and is integral for the interpretation and generalization of research findings (Nigg et al. 2002). Some evidence suggests that for empirical based interventions, strong fidelity is essential to produce treatment effects in real world settings (Hogue et al. 2008). Despite its significance in drawing valid inferences, previous reviews have paid little attention to whether treatment fidelity issues have been addressed by interventions. Therefore, in this review we consider whether studies have measured and/or reported treatment fidelity practices. We considered adherence to intervention content and study design, particularly whether interventions had been designed in line with appropriate theoretical underpinnings, competency of treatment deliverers (i.e. was their competency to deliver the intervention content assessed), treatment delivery (i.e. was the intervention delivered as intended and reported) and, the receipt

of treatment (i.e. was the treatment evaluated from the perspectives of the recipients), and if so, was it received as intended.

Previous reviews have also largely ignored evidence from non randomized controlled trials (Luutikhuis et al. 2009; Summerbell et al. 2003) and while non RCT designs are commonly adopted in the 'real world context', such as the childhood obesity setting, there are a number of potential limitations of the RCT design. Limitations of RCTs include the potential that an RCT is impractical in terms of time and cost implications, the limited transferability of findings from RCTs back into the 'real world context', the potential unethical assignment of participants who require access to a service/treatment to a control group, and a lack of appreciation of complex social phenomenon (Dugdill et al. 2005).

Why a Systematic Review

In this systematic review we complement previous reviews (Luutikhuis et al. 2009; Summerbell et al. 2003), using a quantitative review style that has been adopted in a variety of health care settings to consider the efficacy of current approaches to childhood obesity treatment interventions over the past decade (Goodger et al. 2007; Hutchinson et al. 2008; Sallis et al. 2000). We specifically aimed to address whether childhood obesity treatment interventions have considered and/or assessed treatment fidelity issues (i.e. process evaluation); acknowledging this could enhance the generalizability and replicability of successful interventions (Resnick et al. 2005). The Effect size (ES) was calculated to allow for the consideration of how effective the treatment intervention was versus the control condition, and whether this related to the fidelity of the treatment condition.

We extended commonly adopted review criteria to include non RCTs as well as RCTs. This was particularly relevant considering the emergence of an increasing number of childhood obesity treatment programs post 2000, such as camp based studies that have not been implemented as large RCTs. We discuss findings in line with recent expert recommendations regarding childhood obesity treatment published by Barlow and the expert committee (2007) (see Fig. 1), highlighting limitations and implications for future practice and research in this context.

Method

Sources

The search strategy employed two main sources to locate published studies of child and adolescent overweight and obesity treatments: (1) Electronic searches of computerized

Fig. 1 Barlow and the Expert committees’ recommendations for the treatment of childhood obesity (Barlow 2007)

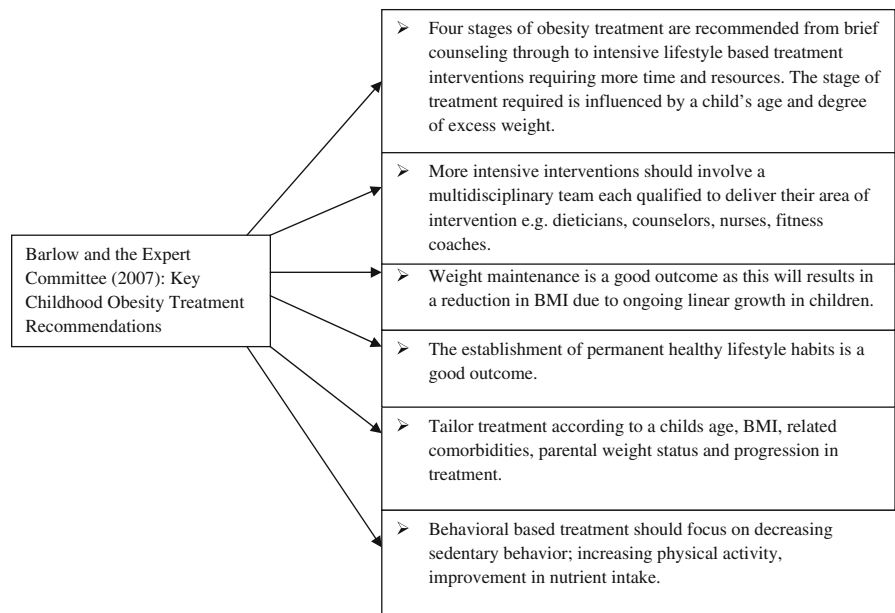
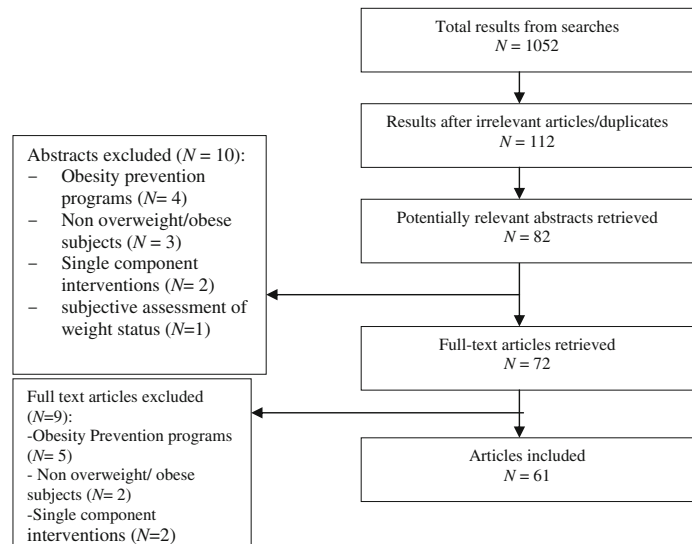


Fig. 2 Summary of outcome of all retrieved papers



databases (SPORTdiscus, PsychINFO, Medline, Scopus, Highwire Press, and PubMed); (2) Citations in papers identified by the electronic searches. Keyword combinations for the electronic database searches included: Childhood and adolescent, obesity and overweight, treatment intervention, weight loss/reduction program, weight management, weight maintenance, weight control program, and healthy lifestyle program. Figure 2 illustrates the study selection procedure and the results of the filtering process.

Inclusion Criteria

Inclusion Criteria for this review were: (1) Data from randomized controlled trials (RCTs) and non-RCTs (including observational studies, pre-post trials, cohort studies:

retrospective and prospective, longitudinal studies, case control or time series), (2) Lifestyle Interventions designed to treat childhood obesity that involves any combination of dietary, physical activity and behavioral therapy, (3) Interventions with both short (less than 6 months), medium (6–12 months) and long-term follow-up (greater than 12 months) were included, (4) Participants in the age range 5–18 years old. (5) Interventions that included at least one objective measure of participants weight status/adiposity (including BMI, BMI-SDS, waist circumference, skinfold thickness and percent overweight) prior to, and post treatment, and (6) Publications from January 2000 to 2009.

Treatment programs were defined as those that involved a primary or secondary goal of weight loss or weight control/weight maintenance/weight management. Family

involvement was defined as having a minimum of one parent or guardian involved in at least one aspect of the treatment.

Exclusion Criteria

Articles were excluded if they were not available in the English Language; unpublished studies and dissertations/theses.

Procedures

Hard copies of all relevant publications were obtained, according to this reviews' inclusion and exclusion criteria. To analyze included publications we followed the descriptive review protocol outlined in Sallis et al. (2000) and adopted by Goodger et al. (2007) and Hutchinson et al. (2008). Each treatment intervention was initially coded with a bibliography number allocated chronologically (see Table 1). Tables 2 and 3 were then created for the selected sample and study characteristics and Table 4 reports the effect sizes of studies. Bibliography numbers were used to identify relevant characteristics of included studies. The treatment fidelity of each study was assessed in terms of study design in terms of whether the intervention was theoretically underpinned, training and competencies of treatment deliverers, treatment delivery, treatment receipt, and enactment of treatment skills (see Table 3).

In order to clarify study details, and assess the potential role of treatment fidelity in each study, an email was sent to the first author of each study. Corresponding authors were asked the following three questions: (1) If not reported here, or elsewhere, was there an underlying theoretical underpinning that influenced the development of the intervention design? (2) If not reported here, or elsewhere, is there any intention to conduct further follow-up assessments of the outcome measures and if so, how long will this follow-up period be? (3) If not reported here, did you have a rationale behind the age group included in the intervention? If so, what was this?

Emails were sent to the first author of each study (N=47), and responses were received from 20 authors (42.6%). Where multiple papers reported interventions conducted by the same author only one email was sent to the first author. Nine out of the 61 studies did not receive an email as no up to date email addresses were available.

Data Extraction and Quality Assessment

Data (sample and study characteristics, intervention design, outcomes, effectiveness, and quality) were independently extracted and reviewed by the first and second author. Where discrepancies occurred we consulted the third author and a consensus was reached. Study quality was

assessed using the American Dietetic Association evidence analysis manual, Fifth Edition (ADA: IV Edition 2005). Following ADA guidelines, studies were rated according to class, which was assessed via study design. Secondly study quality was assessed according to study relevance i.e. the applicability of the research to the childhood obesity treatment context and study validity (i.e. the design and execution of the study). Thirdly, studies were rated according to the strength of conclusion which was determined by the strength of evidence supporting the conclusion. The strength of evidence was assessed according to the quality (i.e. the validity of the study according to the design and execution); the consistency; and the sample size (quantity); the clinical impact (i.e. the importance of the outcome(s) studied and; the generalizability of findings to similar populations). Table 2 details quality ratings for each included study. For a detailed explanation of how quality assessment was carried out see the ADA: Evidence analysis manual Fifth Edition (ADA: IV Edition 2005).

Treatment Effect Size

The ES was calculated to measure how large the treatment effect was. The measure of effect is the magnitude of the distance between two groups means in number of standard deviations. Cohen's *d* (Cohen 1988) was used to calculate the size of the treatment effect as it is a recognized measure of ES and allows the consideration of whether the treatment intervention resulted in a small (≤ 0.2), medium (≤ 0.5), or large effect (≤ 0.8) (Coe 2002). Table 4 presents the ES for the 21 studies that reported sufficient detail to allow the calculation of the ES. The ES was calculated immediately post intervention and for the follow-up period of those studies that reported it.

Results

Sample and Study Design Characteristics

Searches identified 61 relevant articles reported from January 2000 to 2009 that met the inclusion/exclusion criteria and Table 1 presents the bibliography number assigned to each study retrieved. Table 2 reports the study design and sample characteristics. Non RCTs were the dominant design with 40 non-RCTs (65.6%) and 21 RCTs (34.4%). A number of studies did include a comparison condition (18%) and studies with a control group ranged from an advice in one session (1.6%), to typical/standard care (13%), wait list control (4.9%) or a medium intensity intervention (8.2%). There were 19 interventions (31.1%) conducted with children (age 5–12 years old); 16 interventions (26.2%) involved adolescents (12–18 years old),

Table 1 Bibliography details, intervention/study names

Biblio. No.	Name of study/intervention (Year)	Journal
1	Braet and Van Winckel (2000)	Behavioral Therapy
2	Gately et al. (2000)	International Journal of Obesity
3	Sothorn et al. (2000)	Acta Paediatrica
4*	Epstein et al. (2001)	Obesity Research
5	Levine et al. (2001)	International Journal of Eating Disorders
6*	Nova et al. (2001)	Ambulatory Child Health
7*	Warshburger et al. (2001)	International Journal of Obesity
8	Jelalian and Mehlenbeck (2002)	Journal of Clinical Psychology in Medical Settings
9	Saelens et al. (2002)	Obesity Research
10	Sothorn et al. (2002)	Journal of American Dietetic Association
11*	Sung et al. (2002)	Archives of Disease in Children
12	Braet et al. (2004)	Journal of Pediatric Psychology
13	Dao et al. (2004)	International Journal of Obesity
14	Dietrich and Widhalm (2004)	International Pediatrics
15	Epstein et al. (2004)	Health Psychology
16	Golan and Crow (2004)	Obesity Research
17	Gately et al. (2005)	Pediatrics
18*	Jiang et al. (2005)	Archives of Disease in Children
19	Kirk et al. (2005)	Obesity Research
20	Kirschenbaum et al. (2005)	Obesity Research
21	Korsten-Reck et al. (2005)	International Journal of Obesity
22	Lazzer et al. (2005)	International Journal of Obesity
23*	Nemet et al. (2005)	Pediatrics
24*	Resnicow et al. (2005)	Obesity Research
25	Sacher et al. (2005) MEND	Journal of Human Nutrition and Dietetics
26	Savoie et al. (2005)	Journal of American Dietetic Association
27*	Wrotniak et al. (2004)	Obesity Research
28*	Daley et al. (2006)	Pediatrics
29	Edwards et al. (2006)	European Journal of Clinical Nutrition
30	Fennig and Fennig (2006)	European Eating Disorders Review
31	Jelalian et al. (2006)	International Journal of Obesity
32	Rudolf et al. (2006) WATCH IT	Archives of Diseases in Children
33*	Williamson et al. (2006)	Diabetes Research & Clinical Practice
34	Dreimane et al. (2007)	Journal of Pediatric Endocrinology Metabolism
35	Gillis et al. (2007)	Pediatrics
36*	Golley et al. (2007)	Pediatrics
37*	Johnston et al. (2007)	International Journal of Obesity
38*	Kalavainen et al. (2007)	International Journal of Pediatric Obesity
39	Nowicka et al. (2007)	International Journal of Obesity
40	Reinehr et al. (2007)	Journal of Evaluative Clinical Practice
41	Sabin et al. (2007)	Journal of American Medical Association
42*	Savoie et al. (2007) ^a	Journal of Paediatrics and Child Health
43*	Shelton et al. (2007)	BMC Pediatrics
44	Tanas et al. (2007)	BMC Pediatrics
45	van den Akker et al. (2007)	The Journal of Pediatrics
46	Vignolo et al. (2007)	International Journal of Clinical Nutrition
47	Archenti and Pasqualinotto (2008)	Obesity Surgery
48	Craeynest et al. (2008)	Eating Behaviours

Table 1 continued

Biblio. No.	Name of study/intervention (Year)	Journal
49*	Hughes et al. (2008)	Pediatrics
50*	Janicke et al. (2008)	Archives of Pediatrics and Adolescent Medicine
51	Knopfli et al. (2008)	Journal of Adolescent Health
52	Mc Cormick et al. (2008)	Clinical Pediatrics
53	Miller et al. (2008)	Vascular Disease Prevention
54*	Munsch et al. (2008)	Psychotherapy and psychosomatics
55	Nowicka et al. 2007	International Journal of Pediatric Obesity
56	Rice et al. (2008)	Clinical Pediatrics
57	Robertson et al. (2008)	Archives of Disease in Children
58	Schiel et al. (2008)	Journal of Telemedicine Telecare
59	Speroni et al. (2008)	American Journal of Preventive Medicine
60*	Tsiros et al. (2008)	American Journal of Clinical Nutrition
61*	Weigel et al. (2008)	Journal of Nutrition and Education

* Bibliography numbers marked with an asterisk (*) represent those studies that were randomised controlled trials

^a Savoye et al. (2007) represents the same intervention as Savoye et al. (2005). It was considered relevant for inclusion as it was a larger scale RCT so provided different design characteristics than the earlier study

and 26 (42.6%) interventions were aimed at children and adolescents. A large number of studies did not identify the ethnicity (49.2%) or the socio-economic status (67.2%) of the participants and in studies that identified these demographics, samples with a majority of white participants (36.1%), from middle to upper class backgrounds (21.3%), were the most common. In general, the majority of samples included a mixture of male and female participants (96.7%). A small number of studies specifically targeted females (3.3%), African Americans (4.9%) or lower working class samples (4.9%). The percentage of the sample completing the interventions ranged from 50 to 100%.

Out of the 61 studies, 31 (50.8%) used multiple measures to determine treatment effect on the participants weight status including Body Mass Index (BMI); BMI standard deviation score (BMI SDS: z-score); percent BMI; body composition; waist circumference and percent overweight. A large proportion of the interventions were conducted in the USA (39.3%). A number of studies were UK based (13.1%) and interventions in other European countries including Belgium (4.9%), Germany (9.8%), Italy (4.9%) and France (3.3%) were reported. Globally, interventions have been conducted in China (3.3%); Israel (4.9%) and Australia (4.9%).

Treatment Program/Intervention Characteristics and Outcomes

Multiple Components of Treatment Interventions

The majority of studies (72.1%) targeted multiple health behaviors including nutrition, PA and/or sedentary

behaviors coupled with behavioral change/modification strategies and incorporated family involvement (70.5%) (see Table 3). No consistent protocol appeared to have been followed by interventions to guide how these multiple components (i.e. PA, diet, family involvement, and behavioral components) should be applied. The dietary components generally focused on the prescription of a healthy balanced diet (e.g. Craeynest et al. 2008; Fennig and Fennig 2006; Lazzer et al. 2005), and/or education on healthy eating/nutrition (e.g. Reinehr et al. 2007; Rice et al. 2008; Sacher et al. 2005; Tanas et al. 2007) with the traffic light diet representing the most commonly prescribed diet featured in studies (e.g. Epstein et al. 2001, 2004; Jiang et al. 2005; Levine et al. 2001). The traffic light diet involves nutritional education, teaching the participants to increase their intake and availability of foods that are low in fat and high in nutrient density (i.e. “green” foods) and to decrease their intake and availability of foods that are high in fat/sugar and low in nutrient density (i.e. “red” foods). Only one study involved an ‘extreme approach’ using a very low calorie diet (Sothorn et al. 2000).

The PA component of interventions varied considerably. Several studies adopted structured, supervised exercise programs (e.g. Gately et al. 2000; Korsten-Reck et al. 2005; Sacher et al. 2005; Savoye et al. 2005; 2007), while others merely encouraged the participants to set goals to increase their PA (e.g. Resnicow et al. 2005). Behavioral modification techniques such as self-monitoring, rewards and goal-setting were common (e.g. Kirk et al. 2005; Korsten-Reck et al. 2005). A number of interventions adopted structured, cognitive behavioral approaches to promote behavior change (e.g. Braet and Van Winckel 2000; Braet et al. 2004;

Table 2 Sample and study characteristics

Characteristic	Biblio. No.	No. of Studies (%)
<i>Age</i>		
Mixed (5–18 years)	1*, 2, 3, 7*, 12, 14, 17, 19, 23*, 32, 33*, 34, 37*, 40, 41, 43*, 44, 45, 47, 48, 49, 50, 52, 53, 56, 61*	26 (42.6)
Children (5–12 years)	4*, 5, 6*, 11, 15, 16, 18*, 21, 25, 27*, 29, 36*, 38*, 39, 42, 49*, 54*, 57, 59	19 (31.1)
Adolescents (12–18 years)	8, 9*, 10, 13, 20, 22, 24*, 26, 28*, 30, 31, 35, 51, 55, 58, 60*	16 (26.2)
<i>Gender</i>		
Mixed	1, 2, 3, 4*, 5, 6*, 7*, 8, 9*, 10, 11*, 12, 13, 14, 15, 16, 17, 18*, 19, 20, 21, 22, 23*, 25, 26, 27*, 28*, 29, 30, 31, 32, 34, 35, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 45, 46, 47, 48, 49*, 50*, 51, 52, 53, 54*, 55, 56, 57, 58, 59, 60*, 61*	59 (96.7)
Females	24*, 33*	2 (3.3)
<i>Ethnicity</i>		
Not identified	2, 6*, 7*, 14, 16, 21, 22, 23*, 25, 26, 30, 32, 35, 39, 40, 41, 43*, 45, 46, 47, 48, 49*, 51, 53, 54*, 55, 56, 58, 60*, 61*	30 (49.2)
White	1, 3, 4*, 5, 8, 9*, 10, 12, 13, 15, 17, 19, 27*, 28*, 29, 31, 36*, 38*, 44, 50*, 57, 59	22 (36.1)
African American	20, 24*, 33*	3 (4.9)
Diverse sample	42*, 52	2 (3.3)
Chinese	11*, 18*	2 (3.3)
Hispanic	34	1 (1.6)
Mexican–American	37*	1 (1.6)
<i>Socio Economic Status</i>		
Not identified	6*, 7*, 10, 11*, 13, 14, 16, 17, 18*, 19, 21, 22, 23*, 25, 30, 32, 33*, 34, 35, 36*, 37*, 39, 40, 41, 42*, 43*, 45, 46, 47, 48, 50*, 51, 52, 53, 54*, 55, 56, 58, 59, 60*, 61*	41 (67.2)
Upper/Middle Class	2, 3, 4*, 8, 9*, 12, 15, 24, 26, 27*, 29, 31, 38*	13 (21.3)
Diverse sample	1, 44, 49*, 57	4 (6.6)
Lower/working class	5, 20, 28*	3 (4.9)
<i>Main Measure(s) used to assess treatment effect on weight status</i>		
Multiple Measures (any combination of weight change, BMI, BMI SDS, fat mass, waist circumference, skinfold thickness)	3, 5, 10, 11*, 12, 13, 17, 19, 20, 21, 22, 23*, 24*, 25, 26, 32, 33*, 36*, 37*, 38*, 42*, 43*, 44, 45, 46, 51, 52, 54*, 58, 59, 60*	31 (50.8)
BMI Standard Deviation Score (BMI SDS/z score)	2, 9*, 15, 35, 39, 40, 41, 49*, 50*, 53, 55, 57, 61*	13 (21.3)
Body Mass Index (BMI)	14, 18*, 28*, 29, 34, 47, 48, 56	8 (13.1)
Percent overweight	1, 4*, 6*, 7*, 16, 27*	6 (9.8)
Weight change/loss	8, 30, 31	3 (4.9)
<i>Country</i>		
USA	2, 3, 4*, 5, 8, 9*, 10, 15, 16, 19, 20, 24*, 26, 27*, 31, 33*, 34, 37*, 42*, 50*, 52, 53, 56	24 (39.3)
UK	17, 25, 28*, 29, 32, 41, 49*, 57	8 (13.1)
Germany	7*, 21, 40, 54*, 58, 61*	6 (9.8)
Belgium	1, 12, 48	3 (4.9)
Israel	23*, 30, 35	3 (4.9)
Italy	6*, 44, 47	3 (4.9)
Finland	38*, 39, 55	3 (4.9)
Australia	36*, 43*, 60*	3 (4.9)
France	13, 22	2 (3.3)

Table 2 continued

Characteristic	Biblio. No.	No. of Studies (%)
China	11*, 18*	2 (3.3)
Switzerland	51	1 (1.6)
Netherlands	45	1 (1.6)
Austria	14	1 (1.6)
<i>Percentage of Sample Completing Intervention</i>		
90–100%	11*, 13, 15, 17, 18*, 21, 22, 25, 37*, 38*, 43*, 44, 55, 56, 61*	15 (24.6)
70–80%	6*, 9*, 14, 20, 26, 27*, 30, 32, 33*, 49*, 50*, 52, 58	13 (21.3)
80–90%	1, 4*, 8, 23*, 24*, 28*, 29, 36, 39, 40	10 (16.1)
60–70%	3, 5, 10, 12, 45, 46, 57	7 (11.5)
50–60%	2, 34, 42*, 48, 53, 59	6 (9.8)
Not identified	7*, 16, 31, 35, 41, 51	6 (9.8)
<50%	19, 54*, 60*	2 (3.3)
<i>Design</i>		
Non randomized controlled trials	1, 2, 3, 5, 8, 10, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 25, 26, 29, 30, 31, 32, 34, 35, 39, 40, 41, 44, 45, 46, 47, 48, 51, 52, 53, 55, 56, 57, 58, 59	40 (65.6)
Randomized controlled trial	4*, 6*, 7*, 9*, 11*, 18*, 23*, 24*, 27*, 28*, 33*, 36*, 37*, 38*, 42*, 43*, 49*, 50*, 54*, 60*, 61*	21 (34.4)
<i>Study quality ratings</i>		
<i>Class Rating**</i>		
Class D	2, 3, 5, 8, 10, 12, 13, 14, 19, 20, 22, 25, 29, 30, 32, 34, 39, 40, 41, 44, 45, 46, 47, 49, 51, 52, 53, 56, 57, 58, 59	31 (50.8)
Class A	1, 4*, 6*, 9*, 11*, 15, 16, 24*, 27*, 28*, 31, 33*, 36*, 38*, 42*, 43*, 48, 50*, 54*, 60*, 61*	20 (31.1)
Class C	17, 18*, 21, 23*, 26, 35, 37, 55	8 (13.1)
Class B	7	1 (1.6)
<i>Quality rating</i>		
Neutral Ø	2, 3, 5, 6*, 7, 8, 10, 12, 13, 14, 15, 17, 18*, 19, 20, 22, 24, 25, 26, 29, 31, 32, 35, 37, 39, 40, 41, 44, 45, 46, 52, 55, 56, 57, 58	35 (57.4)
Positive +	1, 4*, 9*, 11*, 16, 21, 23*, 27*, 28*, 33*, 36*, 38*, 42*, 43*, 48, 50*, 54, 60*, 61*	19 (31.1)
Negative –	30, 34, 47, 49*, 51, 53, 59	7 (11.5)
<i>Strength of Conclusion</i>		
III (limited/weak)	2, 3, 5, 6*, 7*, 8, 10, 13, 14, 15, 17, 18*, 19, 20, 22, 25, 26, 29, 30, 31, 32, 33*, 34, 35, 37*, 39, 41, 43*, 44, 45, 46, 47, 52, 53, 55, 57, 58, 59	38 (62.3)
II (fair)	1, 4*, 9*, 11*, 12, 16, 21, 23*, 24*, 27*, 28*, 36*, 38*, 40, 42*, 48, 49*, 51, 56, 60*, 61*	21 (34.4)
I (Good/strong)	50*, 54	2 (3.3)
III (expert opinion only)	0	
IV (grade not assignable)	0	

* Bibliography numbers marked with an asterix (*) represent those studies that were randomized controlled trials

** Class rating assessed according to the study design (from Class A randomized controlled trials to Class D before and after study design with absence of a control group)

Craeynest et al. 2008). Cognitive behavioral approaches typically incorporated goal-setting, problem solving, self monitoring of physical activity and nutrition, and stimulus control strategies to try and change the participants thinking and thus encourage behavior change.

Interventions also employed multiple strategies (67.2%) to deliver intervention content and support participant

behavior change. For example, delivery of the behavioral component varied from individually based treatment (e.g. Craeynest et al. 2008; Fennig and Fennig 2006; Hughes et al. 2008; Reinehr et al. 2007), to group based sessions (e.g. Gately et al. 2005; van den Akker et al. 2007), or a combination of group and individual sessions (e.g. Rice et al. 2008; Rudolf et al. 2006) and telephone counseling/

Table 3 Intervention outcome(s) and design characteristics

Characteristic	Biblio. No.	No. of Studies (%)‡
<i>Treatment Fidelity</i>		
Measures of treatment fidelity unreported/unidentified	1, 2, 3, 4, 5, 6*, 7*, 8, 9*, 10, 11*, 12, 13, 14, 15, 16, 17, 18*, 19, 20, 21, 22, 23*, 24*, 25, 26, 27*, 28*, 29, 30, 31, 32, 33*, 34, 35, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 45, 46, 47, 48*, 49*, 50*, 51, 52, 53, 54*, 55, 56, 57, 58, 59, 61*	59 (96.7)
Measures of treatment fidelity reported/identified	54*, 60*	2 (3.3)
<i>Theoretical Underpinning guiding intervention</i> (does not extend to include evidence based programs e.g. programs based on professional guidelines or government guidelines)		
No theoretical underpinning identified	2, 3, 6*, 7*, 8, 9*, 10, 11*, 13, 14, 17, 18*, 19, 20, 21, 22, 23, 24*, 25, 26, 30, 31, 34, 35, 37*, 40, 41, 42*, 43*, 44, 47, 48, 49*, 50*, 51, 52, 53, 55, 56, 57, 58, 59, 61*	43 (70.5)
Other	16, 32, 33, 29, 36*, 38, 39	7 (11.5)
Cognitive Behavioral Theory	1, 12, 45, 54*, 60*	5 (8.2)
Social Cognitive Model/Theory	4*, 5, 15, 27*	4 (6.6)
Transtheoretical Model	28*, 46	2 (3.3)
<i>Interventionists</i>		
Health professionals (i.e. paediatricians, counsellor, nutritionists, physical activity coaching etc.)	1, 2, 3, 4*, 6*, 7*, 8, 9*, 10, 11*, 12, 14, 15, 16, 17, 18*, 19, 20, 21, 22, 23*, 24*, 25, 26, 29, 30, 31, 33*, 34, 35, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 45, 46, 47, 48, 49*, 50*, 51, 52, 53, 54*, 55, 56, 57, 58, 59, 60*, 61*	56 (91.8)
Students with limited training to deliver intervention	5, 28*, 32	3 (4.9)
Not identified	13, 27*	2 (3.3)
<i>Interventionist Competence in delivering treatment</i>		
Competence in delivery not assessed/unidentified	1, 2, 3, 4*, 5, 6*, 7*, 8, 9*, 10, 11*, 12, 13, 14, 15, 16, 17, 18*, 19, 20, 21, 22, 23*, 24*, 25, 26, 27*, 28*, 29, 30, 31, 32, 33*, 34, 35, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 45, 46, 47, 48, 49*, 50*, 51, 52, 53, 55, 56, 57, 58, 59, 61*	59 (96.7)
Competence assessed/identified	54*, 60*	2 (3.3)
<i>Receipt of treatment</i>		
Participant satisfaction not assessed/not identified	1, 2, 3, 4*, 5, 6*, 11*, 12, 13, 14, 15, 16, 17, 18*, 19, 20, 21, 22, 23*, 24*, 25, 26, 27*, 28, 30, 31, 34, 35, 37*, 39, 40, 41, 42*, 44, 45, 47, 48, 49*, 50*, 51, 52, 53, 55, 56, 61*	45 (73.8)
Participant satisfaction assessed/identified	7*, 8, 9*, 10, 29, 32, 33*, 36*, 38*, 43*, 46, 54*, 57, 58, 59, 60*	16 (26.2)
<i>Delivery mode/setting of Intervention</i>		
Specialised/hospital outpatient treatment	1, 3, 6*, 10, 14, 19, 20, 21, 23*, 26, 29, 34, 36*, 39, 40, 41, 42*, 44, 45, 46, 47, 49*, 53, 54*, 57	25 (41.0)
Community setting	8, 24*, 25, 31, 32, 35, 43*, 50*, 52, 56	10 (16.4)
Specialised/hospital in patient treatment	7*, 12, 22, 30, 48, 51, 58	7 (11.5)
Residential Controlled setting	2, 4*, 13, 15, 17, 27, 37*, 55	8 (13.1)
Not identified	5, 11*, 16, 38*	4 (6.6)

Table 3 continued

Characteristic	Biblio. No.	No. of Studies (%)‡
Combination/Mixed Modes of delivery (e.g. primary care and computer support/telephone counselling)	9*, 28*, 50*, 60*, 61*	5 (8.2)
Computer based	33*	1 (1.6)
Home based	18*	1 (1.6)
<i>Duration of Intervention</i>		
Long term (>6 months)	1, 3, 4*, 6*, 10, 12, 13, 14, 15, 18*, 21, 22, 26, 27*, 33*, 39, 40, 41, 42*, 44, 48, 56, 58, 61*	24 (39.3)
Medium (3–6 months)	8, 9*, 16, 19, 20, 23*, 24*, 25, 29, 31, 32, 34, 36*, 37*, 38*, 49*, 50*, 53, 54*, 59, 60*	21 (34.4)
Brief (<12 weeks)	2, 5, 7*, 11*, 17, 28*, 30, 35, 43*, 45, 46, 47, 51, 53, 55, 57	16 (26.2)
<i>Components of the obesity treatment intervention</i>		
Nutrition, exercise and/or sedentary behaviors plus behaviour change/modification (e.g. goal setting, self monitoring, stimulus control)	2, 3, 4*, 5, 9*, 14, 15, 16, 17, 18*, 19, 21, 23*, 24*, 25, 26, 27*, 29, 32, 33*, 34, 35, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 46, 47, 49*, 50*, 51, 52, 53, 54*, 55, 56, 57, 58, 61*	44 (72.1)
Nutrition, exercise and cognitive behavioural treatment (CBT)	1, 7*, 12, 20, 30, 45, 48, 60*	8 (13.1)
Nutrition and Exercise	6*, 11, 59	3 (4.9)
Nutrition, exercise, psychological and/or medical support	10, 13, 22	3 (4.9)
Nutrition, exercise, CBM and Peer based skill training	8, 31	2 (3.3)
Exercise and behavioral change	28*	1 (1.6)
<i>Delivery strategies employed by the intervention</i>		
Multiple/Combination of strategies employed	1, 2, 3, 4*, 6*, 7*, 8, 9*, 10, 12, 14, 15, 17, 21, 22, 24*, 26, 29, 30, 31, 36*, 37*, 38*, 41, 42*, 43*, 44, 46, 47, 48, 49*, 50*, 51, 52, 54*, 55, 56, 57, 58, 59, 60*	41 (67.2)
Group based treatment	5, 16, 20, 23*, 25, 34, 40, 45, 61*	9 (14.8)
Individually tailored support/face to face counselling	13, 18*, 19, 28*, 33*, 39, 53	7 (11.5)
Written material/educational support material	11*, 27*, 35	3 (4.9)
Computer/internet based support material	32	1 (1.6)
<i>Target individuals of the Intervention</i>		
Family	1, 3, 4*, 5, 6*, 8, 9*, 10, 11*, 13, 14, 15, 18*, 19, 20, 21, 23*, 24*, 25, 26, 27*, 29, 31, 32, 33*, 34, 35, 37*, 38*, 39, 40, 41, 42*, 44, 45, 46, 47, 48, 50*, 53, 55, 56, 57	43 (70.5)
Child/Adolescent alone	2, 7*, 12, 17, 22, 28*, 30, 51, 58, 59, 60*, 61*	12 (19.7)
Parent only	16, 36, 43*, 50*, 54*	5 (8.2)
<i>Control Condition</i>		
No control group	2, 3, 5, 8, 10, 12, 13, 14, 16, 19, 20, 22, 25, 26, 29, 30, 31, 32, 39, 41, 45, 46, 47, 48, 51, 53, 54*, 56, 58, 59	30 (49.2)
No intervention comparison group	17, 18, 21, 23*, 33*, 34, 35, 36*, 40, 43, 52	11 (18.0)

Table 3 continued

Characteristic	Biblio. No.	No. of Studies (%)‡
Medium Intensity Intervention	4*, 7*, 24*, 37*, 42*, 54*	6 (9.8)
Typical care	6*, 9*, 15, 27*, 28*, 38*, 44, 49*	8 (13.1)
Wait list control group	50*, 55, 60*	3 (4.9)
Educational material	11*, 61*	2 (3.3)
Advice in one session	1	1 (1.6)
<i>Outcome Measures (excluding measures of adiposity)</i>		
Physiological measures	14, 18, 19, 21, 24*, 25, 30, 34, 36*, 37*, 40, 42*, 44, 45, 46, 50*, 51, 56	19 (31.1)
Behavioral measures	4*, 6*, 7*, 9*, 11*, 15, 20, 23*, 27, 43, 44, 48, 50*, 53, 57, 58, 59, 60*	18 (29.5)
Psychosocial Measures	1, 4*, 5, 7*, 8, 25, 26, 28*, 29, 39, 46, 44, 51, 54*, 57, 58	16 (26.2)
Evaluation/Participant satisfaction	7*, 8, 9*, 10, 29, 32, 33*, 36*, 38*, 43*, 46, 57, 58, 59	14(23.0)
Other measure(s)	2, 4*, 8, 21, 22, 23*, 25, 28*, 35, 46	10 (16.4)
Adherence Measure	6*, 27*, 50*, 52, 54*, 57, 58, 59	7 (11.5)
Eating Disorder Measure/measure of unintended effects	1, 5, 12, 29, 33, 54*	6 (9.8)
No other outcomes reported	16, 17, 47, 55	4 (6.6)
<i>Follow Up†</i>		
6 to 12 months	2, 4*, 5, 6, 7*, 8, 13, 15, 21, 23*, 24*, 31, 33*, 36*, 38*, 45, 48, 49*, 50*, 54*, 55, 57, 58	23 (37.7)
No follow up post intervention	3, 10, 11*, 14, 17, 18*, 19, 20, 32, 34, 37*, 39, 41, 42*, 47, 51, 52, 53, 56, 60*	20 (32.7)
>12 months	1, 12, 16, 26, 27*, 30, 40,44,46	9 (14.8)
<6 months	9*, 22, 25, 28*, 29, 35, 43*, 59, 61*	9 (14.8)
<i>Significantly Effective** (Pre-Post treatment on at least one measure of adiposity)</i>		
Significantly effective	2, 3, 4*, 5, 6*, 7*, 8, 9*, 10, 12, 13, 14, 15, 16, 17, 18*, 19, 21, 22, 23*, 25, 26, 27*, 29, 30, 31, 32, 33*, 34, 36*, 37*, 38*, 39, 40, 41, 42*, 43*, 44, 45, 46, 48, 50*, 51, 53, 54*, 55, 56, 57, 58, 59, 60*, 61*	52 (85.2)
Not significantly effective	1, 11*, 20, 24*, 28*, 35, 47, 49*, 52	9 (14.8)
<i>Significantly Effective** (At follow up reflected by at least one measure of adiposity)</i>		
No follow up post intervention reported	3, 10, 11*, 17, 18*, 19, 20, 32, 34, 37*, 39, 41, 42*, 47, 51, 52, 53, 56, 60*, 61*	20 (31.1)
Medium Term (6–12 months)	4*, 6*, 7*, 8, 13, 14, 15, 22, 23*, 26, 31, 36*, 45, 48, 50*, 54*, 57, 58	18 (29.5)
Non significant at follow up	2, 5, 9*, 21, 24*, 25, 28*, 33*, 35, 38*, 49*	11 (18.0)
Long Term (12 months +)	1, 12, 16, 26, 27*, 30, 40, 44, 46	9 (14.8)
Short Term (<6 month follow up)	29, 43*, 59	3 (4.9)

* Bibliography numbers marked with an asterisk (*) represent those studies that were randomized controlled trials

‡ Primary Goal as defined by authors

† Follow-up was measured from treatment intervention termination to last follow up measurement recorded

** Effective refers to whether the primary treatment intervention arm was concluded to be effective by authors in terms of its ability to induce weight loss/weight maintenance in the short term, medium and long term

Table 4 Treatment effect sizes for RCTs and controlled trials

Study and Bibliography Number	Study Design	Primary Outcome Variable (s)*	Length of Intervention	Effect Size (ES) Immediately Post Intervention ^a	Length of Follow up	Effect Size at follow up
6. Nova et al. (2001)	RCT	BMI	6 months	0.5	12 months	0.5
		Percent overweight		0.5		0.4
7. Warshburger et al. (2001)	RCT	Percent overweight	6 weeks	0.12	12 months	NA
9. Saelens et al. (2002)	RCT	BMI	4 months	0.4	12 months	0.3
		Percent overweight		0.3		0.3
11. Sung et al. (2002)	RCT	BMI	6 weeks	0.24	0	NA
17. Gately et al. (2005)	Controlled trial	BMI	6 weeks	0.5	0	NA
		BMI SDS		0.6		
18. Jiang et al. (2005)	RCT	BMI	2 years	1.8	0	NA
21. Korsten-Reck et al. (2005)	Nonrandomized clinical observation study	BMI	8.5 months	0.3	0	NA
		BMI SDS		0.3		
23. Nemet et al. (2005)	RCT	BMI	3 months	1.4	12 months	0.4
		BMI SDS (only available at 12 months follow up)				2.1
24. Resnicow et al. (2005)	RCT	BMI	6 months	0.07	12 months	0.01
28. Daley et al. (2006) ^b	RCT	BMI SDS	14 weeks (intervention gp)	0	28 weeks	0.2
			14 weeks (placebo gp)	0.7	28 weeks	1
33. Williamson et al. (2006)	RCT	BMI	24 months	0.1	0	NA
		BMI SDS		0.0004		
36. Golley et al. (2007) ^b	RCT	BMI SDS (parenting plus lifestyle programme)	12 months	0.3	0	NA
		BMI SDS (parenting alone)		0.04		
37. Johnston et al. (2007)	RCT	BMI	3 months	1.42	6 months	1.5
		BMI SDS		0.9		0.9
38. Kalavainen et al. (2007)	RCT	BMI	6 months	0.8	6 months	0.6
		BMI SDS		0.3	6 months	0.3
42. Savoye et al. (2007)	RCT	BMI	6 months	0.47	12 months	0.47
43. Shelton et al. (2007)	RCT	BMI	3 months	0.5	0	NA
50. Janicke et al. (2008) ^b	RCT	BMI SDS (family based)	4 months	0.4	10 months	0.7
		BMI SDS (parent-only)		0.7		0.6
52. Mc Cormick et al. (2008)	Controlled trial	Weight change per month	6 months	0.2	0	NA
54. Munsch et al. (2008)	RCT	Percent overweight (mother only CBT group)	6 months	0.29	6 months	0.32

Table 4 continued

Study and Bibliography Number	Study Design	Primary Outcome Variable (s)*	Length of Intervention	Effect Size (ES) Immediately Post Intervention ^a	Length of Follow up	Effect Size at follow up
60. Tsiros et al. (2008)	RCT	BMI	10 weeks (initial phase)	0.2	20 weeks (maintenance phase)	0.3
61. Weigel et al. (2008)	RCT	BMI BMI SDS	6 months	0.1 0.75	12 months	1.2 1.12

NA Not applicable: were studies did not report a follow-up period an ES could not be calculated

* The ES was calculated for the primary outcome variable used by studies to reflect weight change. BMI and BMI SDS were the most consistent measure used to report weight change across studies therefore the ES was calculated for BMI and BMI SDS. Where BMI and BMI SDS data was not available, the ES was calculated using the primary outcome variable used to report weight change (i.e. percent weight change) in that specific study

^a Effect Sizes (ESs) were calculated using data for completers of the intervention

^b Where two intervention arms were reported, ESs were calculated for each intervention arm

Where standard errors were reported the following equation was used to calculate SD = SE \sqrt{n} (where SE= standard error and n= number of subjects)

support (e.g. Resnicow et al. 2005). Only two studies (3.3%) adopted computer/internet mediated or computer supported programs (Saelens et al. 2002; Williamson et al. 2006). The intensity of professional contact time throughout interventions varied from weekly treatment sessions (e.g. Dietrich and Widhalm 2004) to phased treatment that progressively decreased the intensity of professional support (e.g. Reinehr et al. 2007).

A number of studies identified ways in which interventions tailored and/or individualized treatment. Interventions were tailored according to the participants' weight status (e.g. Sothorn et al. 2000) or the participants' cognitive developmental age (e.g. Golley et al. 2007; Fennig and Fennig 2006; Kalavainen et al. 2007; Saelens et al. 2002). Individualized approaches included personal goal-setting regarding target behaviors (e.g. Jiang et al. 2005; Kirk et al. 2005), individual contracts (e.g. Williamson et al. 2006), personalized diet and PA plans (e.g. Fennig and Fennig 2006; Hughes et al. 2008; Rice et al. 2008; Lazzar et al. 2005) and motivational interviewing (e.g. Resnicow et al. 2005).

Over a third of interventions (39.3%) were categorized as long term (<6 months duration), while 21 studies (34.4%) were categorized as medium term duration (3–6 months duration), and 16 studies (26.2%) were categorized as brief duration (<3 months duration). A number of interventions were delivered from specialized or supervised settings that ranged from controlled/supervised residential settings (13.1%), to specialized hospital inpatient (11.5%), or outpatient settings (41.0%).

Treatment Fidelity

The findings revealed that the majority of studies (70.5%) did not explicitly identify theoretical underpinnings in the

development of the intervention. Only seven studies (11.5%) explicitly detailed the development of the intervention with reference to underlying theory (e.g. Daley et al. 2006; Epstein et al. 2001, 2004; Golley et al. 2007; Levine et al. 2001; Nowicka et al. 2007; Wrotniak et al. 2004). However, author responses established a further seven studies that used underlying theory to develop component(s) of the intervention which had not been originally reported. For example, Braet et al. (2004) used cognitive behavioral theory to develop their intervention and Nowicka et al. (2007) used family therapy and solution focused therapy as a theoretical framework.

Measures of treatment fidelity practices, particularly in terms of adherence to theoretical underpinnings, (i.e. if the intervention was theoretically underpinned) intended intervention content, competence of treatment deliverers (i.e. their training and skills relevant to delivering the intervention) and whether treatment was delivered as intended were rarely acknowledged and/or measured (3.3%). Of the 61 interventions, 56 (91.8%) were delivered by 'trained professionals' (e.g. exercise specialists, nutritionists, and psychologists) yet details of the training or specific skills that professionals had (and their subsequent competence) to deliver the specific intervention content was largely unreported. In terms of receipt of treatment, less than a quarter of studies assessed participant satisfaction (23%).

Treatment Outcomes

Aside from weight related measures, treatment effect was also reflected through measures of physiological outcomes (31.1%), measures of behavior change (26.2%) and psychosocial measures (26.2%). Other outcome measures included unintended effects (9.8%) and adherence to

treatment (11.5%). From pre-post treatment, effectiveness was concluded in terms of weight loss or maintenance, as reflected in the anthropometric measure that each study used to report weight change (i.e. percent overweight, BMI and/or BMI SDS), and a high proportion of the treatment interventions were reported as effective immediately post intervention (85.2%) with almost a third reported medium term effectiveness (6–12 months). However, long term effectiveness (over 12 months) was reported by only nine out of the 61 interventions (14.8%).

Treatment Effect Size

Table 4 details the ES for 21 studies. Of the 21 studies that we calculated the ES for, immediately post intervention, only five studies (23.8%) reported a large ES (e.g. Gately et al. 2005; Janicke et al. 2008; Johnston et al. 2007; Nemet et al. 2005; Weigel et al. 2008), seven studies (33.3%) reported a small ES (e.g. Mc Cormick et al. 2008; Resnicow et al. 2005; Tsiros et al. 2008; Warshburger et al. 2001) and nine studies (42.8%) reported a medium ES (e.g. Kalavainen et al. 2007 Munsch et al. 2008; Shelton et al. 2007). Of the 21 studies that the ES was calculated for the length of intervention and the length of follow-up was variable and of the five studies that reported a large ES, none of them reported follow-up beyond 6 months. Only one of the 21 studies that the ES was calculated for included follow-up beyond 12 months (Williamson et al. 2006) which was a 2 year trial and only reported a small ES. Of the five studies that reported a large ES, they were all multifaceted interventions delivered by health professionals, that where of medium to long term duration. Yet none assessed the fidelity of the treatment interventions and none reported long term follow-up (>6 months). Munsch et al. (2008) and Tsiros et al. (2008) were the only studies that reported the fidelity of the treatment interventions and both had a medium ES (i.e. 0.32 and 0.3 respectively).

Discussion

The present study considered the efficacy of childhood obesity treatment interventions over the past decade, and is the first review of childhood obesity treatment interventions that identified whether interventions have assessed and/or addressed treatment fidelity issues. A further aim was to examine findings in line with recently published expert recommendations regarding the treatment of childhood obesity, highlighting implications for future research and practice that are accessible to stakeholders involved in the provision of childhood obesity treatment (Luutikhuis et al. 2009).

The review reiterates the need for treatment interventions that are family-based, taking a holistic approach to incorporate physical activity, diet and psychological components and tailoring treatment to the target population, in line with most recent expert recommendations (Barlow 2007). There was a clear trend moving away from traditional RCT approaches towards adopting non RCT approaches. Clearly the dominance of non-RCTs (65.6%) affirms that reviews in real world settings, such as childhood obesity treatment, need to adopt broad inclusion criteria, including evidence from non RCTs that are likely to have been limited by practical or ethical concerns associated with the RCT design and thus not been able to include a control group (Dugdill et al. 2005; Sibbald and Roland 1998). Furthermore, findings from RCTs have limited transferability to real world settings and can lack appreciation of complex social phenomenon (Dugdill et al. 2005). Recognizing the demand for funders within the public health domain to establish treatment services on the back of research programs we need to generate and consider evidence where RCTs or the inclusion of a control group is difficult (Flynn et al. 2006).

Treatment Settings

We were encouraged to see community-based and brief interventions emerging that reported positive outcomes (e.g. Mc Cormick et al. 2008; Sacher et al. 2005; Shelton et al. 2007). Promising community-based and/or brief treatment interventions could offer cost-effective treatment options compared with the more traditional and expensive approach of offering intensive programs run from specialized settings (Summerbell et al. 2003). Although only two studies employed computer and internet mediated approaches, these also offer a feasible and economical platform to support and deliver weight loss/weight maintenance treatment programs (Harvey-Berino et al. 2004; Womble et al. 2004).

Treatment Fidelity

The need for treatment fidelity in terms of a sound study design in line with relevant theoretical underpinnings; assurance on the competence and reliability of the intervention and interventionist; and ensuring the intervention is received as intended is clear (Bellg et al. 2004; Breckon et al. 2008). However while this approach seems widely appropriate, the reporting of such facets in research is scant (Bellg et al. 2004).

Munsch et al. (2008) and Tsiros et al. (2008) were the only two studies that explicitly detailed all aspects of treatment fidelity. Munsch et al. (2008) used independent, outside evaluators to assess adherence to treatment

protocol; interventionist competency to deliver the intervention and; the suitability of treatment from the participants' perspectives. There were no differences in the participants' satisfaction, the quality and competency of the therapists' delivery and adherence to intervention content in both of the cognitive behavioral based treatment conditions (parent only group vs. parent and child group). Authors concluded that overweight reduction was not as pronounced as in other similar CBT based treatment interventions. However, the replicability, and the strength of conclusions of this study is greater given the explicit reporting of treatment fidelity thus enhancing the study quality (Resnick et al. 2005).

In the absence of treatment fidelity data it is impossible to determine whether poor child weight related outcomes resulted from an ineffective intervention or an effective intervention that was poorly implemented (Hogue et al. 2008). Therefore studies within this review that concluded treatment effectiveness without demonstrating the key facets of treatment fidelity (e.g. Dietrich and Widhalm 2004; Knopfli et al. 2008) are not replicable and raise questions regarding what were the specific features of these interventions that made them effective (i.e. was it the quality of care from the deliverers, the intensity of the physical activity component or the dietary prescription, etc.). Some studies did report aspects of treatment fidelity more frequently than others (e.g. van den Akker et al. 2007; Edwards et al. 2006); these studies identified the theoretical underpinnings and the receipt of treatment, measuring participant satisfaction. A logical step to strengthen treatment interventions would be to report all facets of treatment fidelity to ensure reliable, competent and theoretically sound interventions that are successful, can be replicated.

Treatment Effect Size

There was clearly variation in the size of effect reported by treatment interventions. Five studies reported a large ES, yet the majority of the studies reported a small to medium ES. All of the five studies that reported a large ES included a physical activity, dietary and behavioral component, and incorporated the whole family, yet these interventions were of different intensities, involved variability in the intervention components and length of treatment intervention, thus there is not enough evidence to support one intervention format over another (Snethen et al. 2006).

Out of the 21 studies that we calculated the ES for, only Munsch et al. (2008) and Tsiros et al. (2008) assessed the fidelity of treatment and both only reported a small to medium ES, yet as they reported treatment fidelity this gives greater potential to explain why a smaller ES was reported in order to modify and enhance the effectiveness

in the future (Resnick et al. 2005). For example Munsch et al. (2008) highlighted that participants consistently, positively rated the suitability of the treatment condition in the mother only CBT and in the mother and child CBT group. Therefore they could firmly conclude that the results were down to the intervention rather than any extraneous variables (Munsch et al. 2008). To allow for the valid comparison of treatment effects and identification of the specific features of effective, multifaceted behavioral treatment interventions, the fidelity of the treatment intervention should be reported (Moncher and Prinz 1991).

Tailoring Treatment Interventions

Expert recommendations emphasize treatment interventions need to be tailored to the participants needs and highlight age as a key factor to recognize when considering the intensity of the intervention yet, almost half of the interventions were not age tailored (i.e. targeted a large age range from 5–18 years old). Only four studies tailored interventions according to the age of the child (Fennig and Fennig 2006; Golley et al. 2007; Kalavainen et al. 2007; Saelens et al. 2002), all of which produced significant weight reductions. Given that children differ metabolically, developmentally, emotionally, and nutritionally across the three childhood phases (i.e. infancy, childhood, and adolescence), we need further RCT's to compare the effectiveness of age tailored treatment versus standardised treatment options (Summerbell et al. 2003).

Limited research has addressed recommendations to actively recruit and tailor treatment interventions to ethnically diverse and immigrant populations (Flynn et al. 2006; Summerbell et al. 2003). When reported, studies generally involved white, middle/upper class samples. Future research targeting diverse populations, specifically groups with the highest prevalence of obesity are still required to avoid taking a "one size fits all" approach. In the UK, for example Asian communities, lower social class groupings and Afro-Caribbean populations have been identified as having a higher prevalence of obesity than their middle class/white counterparts (Jebb et al. 2003), therefore as researchers we need to develop treatment interventions that tailor behavioral recommendations in line with families specific cultural values (Barlow 2007).

Implications for Practice

Practitioners should design obesity treatment interventions based on appropriate theoretical principles as those underpinned by relevant theory have been associated with the most promising outcomes (e.g. Braet et al. 2004, Resnicow et al. 2005). Practitioners should also explicitly detail their philosophy of practice, theoretical

underpinnings, treatment protocol and ensure objective measurement of all facets of treatment fidelity to ensure the intervention was delivered and received as intended to allow future replication of effective programs. Practitioners would benefit from recruiting independent professionals to evaluate such issues around treatment fidelity. Service users should adopt empirically based interventions, taking a holistic approach to treatment that targets the whole family, encouraging physical activity and dietary behavior change through behavioural modification techniques (e.g. goal setting, self monitoring, and positive reinforcement). Evidence suggests that family based multi-dimensional interventions are effective in producing weight loss in children (e.g. Epstein et al. 2001, 2004; Levine et al. 2001; Nova et al. 2001; Sacher et al. 2005). Behavioral interventions adopting cognitive behavioral strategies have shown positive effects on weight related outcomes and should be considered by practitioners as part of multi component programs. Programs should consider the suitability of treatment, varying the intensity of the treatment according to participant's motivation, age, degree of obesity, health risks, and their response to treatment (Barlow 2007). Practitioners should consider maintenance strategies to provide low intensity ongoing support to facilitate adherence to lifestyle change in the long term, post treatment. A potential strategy to reduce dropout rates would be to assess potential participants regarding their readiness to change in order to screen out individuals not ready to commit to treatment.

Computer mediated treatment programs (e.g. Williamson et al. 2006) may offer a cost-effective alternative to traditional and expensive face-to-face methods and should be considered, particularly in light of the growing computer usage among children. Qualitative methodologies should be included to allow stakeholder involvement in the designing of future programs (Flynn et al. 2006) and to assess the impact of interventions beyond the program outcome measures from both the deliverers and the participant's perspective (e.g. Rudolf et al. 2006).

Implications for Research

Treatment interventions need to identify and objectively assess all facets of treatment fidelity. These include; adherence to treatment content; practitioner competence in delivery of the intervention and participant satisfaction to evaluate whether the program was delivered and received as intended and enhance the reproducibility of successful treatment in the future (Resnick et al. 2005). This approach is fundamental and has been applied successfully in health psychology (e.g. Bellg et al. 2004). To improve study quality and strengthen conclusions drawn from treatment programs we need large scale RCTs to test interventions

that have been effective in smaller scale studies. A priority issue is the design and validation of appropriate measurement tools to assess specific behavioral and psychosocial outcomes. Future studies should report follow-up data beyond 1 year to assess sustainability of treatment outcomes (e.g. Golan and Crow 2004, Reinehr et al. 2007). We require further research to establish the efficacy of brief and/or community-based interventions in comparison to more traditional intensive interventions delivered in specialized settings. RCTs are necessary, both in wider contexts (e.g. UK) and in adolescent populations if we are to draw valid conclusions on the effective treatment of childhood obesity. Qualitative work considering the perspectives of key stakeholders regarding current obesity treatment options could contribute to the development of effective, sustainable treatment programs. Continued generation of quality reviews are necessary to provide recommendations that interventions can use to enhance the design of future treatment programs.

Research with diverse subgroups e.g. ethnic minority groups, immigrant populations, socioeconomic groups and religious groups are still required, specifically in those groups identified with higher prevalence rates of overweight/obesity. This might help to identify specific strategies for treatment in these subgroups. Limited data still exists on the potential unintended effects (i.e. eating disorders) that could result from obesity treatment as only six studies assessed the potential for this. Accurate reporting of treatment ES and the fidelity of treatment will contribute to allowing valid comparisons of similar treatment interventions, ensuring effective replication of treatment interventions that report a larger ES and could contribute to the development of standardised multicomponent treatment interventions which are necessary (Moncher and Prinz 1991; Snethen et al. 2006).

Limitations of the Review

Although a large number of interventions fulfilled the inclusion and exclusion criteria, these were tailored to the specific aims of the review. As we included both random and non-randomized trials, the quality of data was limited in some studies due to no control group; non random assignment to the treatment, unreliable outcome measures, small sample sizes and relatively high dropout rates, thus limiting confidence to draw firm conclusions. We could only calculate the ES for 21 studies, therefore it was recognized that we could not directly compare ES for the other 40 studies that were included in the review.

We conducted no hand searches of journals and inclusion criteria did not extend to include unpublished studies and PhD theses, thus we acknowledge the potential for file drawer bias. However, we felt it was important to include

studies that were internationally comparable and available. We believe the search strategy employed here, and adopted in previous reviews (Goodger et al. 2007; Hutchinson et al. 2008; Sallis et al. 2000) generated all relevant studies. Author contact resulted in a moderate 42.6% response rate, which could limit the accuracy of details reported from interventions. Although we recognize systematic reviews need to be comprehensive, for the purpose of brevity only the most pertinent examples were cited in the results section yet all results are reported in Tables 2 and 3. Also, this review did not include single component interventions (e.g. low glycaemic index diet), or alternative treatments (e.g. drug treatment or surgery) that could offer effective treatment options, although these approaches have been subject to review elsewhere (Flynn et al. 2006; Gibson et al. 2006; Luitikhuis et al. 2009; van Sluijs et al. 2007).

Conclusions

Overall this study confirms that health professionals should adopt multi-faceted approaches to treating childhood and adolescent obesity. Treatment should encourage a whole family approach to target physical activity and dietary behavior change, adopting behavioral change strategies including goal setting, self monitoring, and stimulus control. Treatment interventions should measure all aspects of treatment fidelity involving independent, outside evaluators where possible, to ensure objective assessment of treatment effectiveness. This review highlights where it is not feasible to conduct large scale RCTs, non RCTs should be considered to test the efficacy of certain treatment approaches before running as large scale RCTs.

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