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Obesity Management

Immersion treatment of childhood and adolescent obesity: the first review of a promising intervention

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Summary

Obese children have attended weight loss camps and residential programmes for more than 40 years. This paper provides the first systematic review of the effects of those programmes. Twenty-two studies met inclusion criteria (targeted and assessed change in weight status, minimal stay of 10 days and nights). Similar components across programmes included controlled diet, activities, nutrition education, and therapy and/or education regarding behaviour change. Participants lost substantial amounts of weight in all 22 studies, as measured by reductions in per cent-overweight during intervention. Eleven programmes included long-term follow-up evaluations. Compared with results highlighted in a recent meta-analysis of out-patient treatments, these immersion programmes produced an average of 191% greater reductions in per cent-overweight at post-treatment and 130% greater reduction at follow-up. Furthermore, mean attrition rates were much lower when compared with standard out-patient treatment. Inclusion of a cognitive–behavioural therapy (CBT) component seemed especially promising; follow-up evaluations showed decreased per cent-overweight at follow-up by an average of 30% for CBT immersion programmes vs. 9% for programmes without CBT. Explanations for the potentially greater impact of immersion relative to out-patient treatments are presented, including possibly differential effects on self-efficacy for both children and their parents.

Keywords: Child and adolescent obesity, immersion, treatment review.

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Introduction

Obesity has become a global epidemic (1) and a public health crisis (2,3). Among children in the USA, prevalence rates (4) have tripled recently, with 16% of American children and adolescents now obese. An additional 18% are overweight (3). European rates are quickly approaching US numbers (5). These overweight young people are far more likely to become obese adults than their lean peers (6). They are also more likely to develop Type II diabetes, cardiovascular problems, many forms of cancer and other health problems (7). In addition, overweight adolescents suffer from remarkably unfavourable stereotypes that can contribute towards decreased quality of life and increased probability of depression, suicide, academic difficulties, vocational limitations and social challenges.

Fortunately, treatment can improve health, physical fitness, moods and psychosocial functioning (4,8–12). Recent recommendations (13,14) strongly encourage treatment of childhood obesity, but the relative effectiveness of different interventions remains unclear. Education, out-patient cognitive–behavioural therapy (CBT), surgery and immersion are the four primary interventions currently used to treat childhood and adolescent obesity.

Education

Educational interventions are the most widely used approaches to prevent and treat paediatric obesity. The results of these interventions, however, do not seem promising. Stice *et al.* (15) provided the first comprehensive meta-analytic review of the effects of educational interventions designed to decrease body mass indexes (BMIs). Many of the 64 programmes examined were described as preventive, but most included overweight children and all targeted improvements in BMI. Although most of these programmes lasted 6 months or longer, only 21% produced statistically reliable reductions in BMI. The reviewers described the average effect size ($r = 0.04$) as so small that it 'would be considered trivial by most researchers and clinicians.' Only three programmes, 5% of those evaluated, produced significant effects that persisted over time.

In a very recent randomized controlled trial (the largest ever conducted), Wake and her colleagues (16) in Australia obtained results that coincide with the conclusions from this meta-analysis; Wake *et al.* found that family-based educational and behavioural consultations provided by primary care physicians did not improve overweight status of mildly obese 5- to 10-year-olds compared with controls when assessed at 6- or 12-month follow-ups.

Out-patient treatments

Wilfley *et al.*'s (4) meta-analysis documented average decreases in per cent-overweight at follow-up of 8.9% for out-patient CBT programmes. These interventions, on average, produced statistically and clinically significant long-term effects, coinciding with conclusions of other reviewers that out-patient CBT often produces positive effects (15,17,18). However, several studies of out-patient CBT programmes have documented little or no change over time despite high-quality CBT interventions (18–21).

Factors that contribute to the variability in outcomes in out-patient CBT approaches include practical challenges. Stice *et al.* (15) found that shorter educational programmes actually produced better effects than longer ones, perhaps suggesting that practical problems associated with long out-patient programmes, such as transportation and other commitments, may decrease their potential impact. In addition, relatively modest weight losses and inconsistencies in weight change from week to week in out-patient treatment may frustrate participants and their parents. Kaplan and Atkins (22) documented that when participants do not see significant weight losses consistently, they discontinue treatment altogether far more often than when they see consistent changes. Discontinuing treatment generally translates to failure to lose weight (23). Approaches that produce more dramatic, consistent weight changes and decrease attrition more generally may have a better chance of demonstrating improved outcomes in the long run (23–28).

Surgery

Bariatric surgery holds some promise, but this extreme intervention may have substantial side effects and is only available for limited numbers of extremely overweight young people. For example, preliminary analyses (29) estimate that more than 1 million adolescents between age 13 and 21 years in the USA have a sufficiently high BMI (35 or greater) to justify consideration for bariatric surgery. That is less than 5% of the currently obese and overweight teenagers and young adults in the USA. Furthermore, efficacy and safety concerns for bariatric treatments for youth still require additional research (9,30). For example, mortality rates for post-surgery adults remain high, with a recent estimate of 2.8% mortality at 90 d and 4.6% at 1 year (31). Outcomes may be better for children, however. Pratt and others (32) recently concluded, 'data indicate that patient safety and weight loss outcomes for adolescents who undergo weight loss surgery are comparable to, or better than, those seen in adults (p. 902).' In view of the irreversible nature of many of these surgeries, other treatments that prove effective deserve close scrutiny.

Immersion

Immersion treatment places overweight young people in a therapeutic and educational environment for extended periods of time, thereby removing them from obesogenic environments. Although several recent reviews concluded that immersion was a promising alternative treatment, none has provided a comprehensive analysis of evaluations of immersion treatments. For example, Latzer and colleagues (33) reviewed only about a third of the available published studies on this topic, while Spear *et al.* (17) did not describe any specific immersion programmes.

One expert group recently emphasized the potential of immersion treatment (14). The seven-step model (see Fig. 1) suggests that parents have the best chance of producing favourable outcomes to ameliorate their child's obesity if they advance through the steps, from one to seven if necessary. It asserts that that long-term immersion treatment may be the most intensive and most effective non-surgical intervention. This assertion was derived from research on immersion treatments that has not as yet been subject to a formal review. Therefore, in view of these favourable perceptions of immersion treatment combined with some concerns about the limitations of alternative educational, out-patient and surgical interventions, we

Figure 1 Seven steps to success model of treatment of childhood and adolescent obesity. Reprinted with permission from the publisher, Liebert Inc. (14)

attempted to survey and analyse all of the available research on the effects of immersion treatments on childhood obesity.

Method

Procedure and organization

The authors reviewed works from 1958 to 2008. Inclusion criteria were: (i) intervention focused on an immersion environment, i.e. a residential summer camp, in-patient or school setting, where the participant remained in the controlled environment day and night; (ii) treatment lasted at least 10 continuous days (34–36) and (iii) outcomes included assessment of weight change (lb or kg lost, change in BMI, BMI-standard deviations (SDS) or per cent-overweight).

We selected 10 d as a minimal level based on the results of an early immersion trial (34) that lasted 10 d and found significant positive effects after 3.6 years of follow-up (average reduction in per cent-overweight = 15). We defined a follow-up phase in accord with the definition used by Goldfield *et al.* (19); treatment was considered ongoing if participants interacted in person with therapeutic staff within 6 weeks of leaving immersion.

The authors performed searches September to November 2008 of MEDLINE, EBSCO, OCLC/FirstSearch and PubMed. Search terms included 'immersion treatment for obesity', 'children and weight loss camp', 'weight loss camp', 'summer camp and weight loss' and 'residential weight loss'. A total of 260 citations were found. Twenty-two articles met criteria for inclusion. Evaluations not meeting criteria were (i) held for fewer than 10 d; (ii) enrolled only adult (18 years+) participants and/or (iii) did not report weight loss/change data. We also excluded non-English articles, dissertations and theses, programme descriptions and treatment reviews.

Results

Table 1 presents descriptive information for all 22 studies. All studies reviewed included participants who were overweight or obese. Most (63.6%) either reported directly that weight status (BMI, %ile BMI, per cent-overweight) was part of their inclusion criteria, or indicated that all participants had BMI > 30. Only one study (37) included non-overweight participants (BMI range 20.2–67.6). These participants were alumna of the camp from the previous year and were ostensibly overweight at one time. Thirty-three per cent of studies indicated their participants were in 'good physical health' (defined as having no comorbidities other than those attributable to obesity). Similar elements across camps and treatment settings appeared, including a dietary component, physical exercise/activity requirements or opportunities, education in nutrition and cooking, opportunities for regular therapy and/or psychoeducation towards behaviour change. Some studies also offered interventions that involved families.

Components of treatment

Diet component

All programmes used restricted diets, although four studies did not provide descriptions of their diets (24,38–40). The majority of diets focused on calorie restriction, ranging from specific maximum calorie allowances to calorie limits based on body composition. Calories allowed ranged from 1170 (41) to 2300 kcal d^{-1} (25). Some diets included both calorie restriction and recommended nutrient intake, for example, 55% carbohydrate, 30% fat, 15% protein, indicating moderate fat restriction in the diet as well as calorie count (26). Several programmes (34–36,42–44) utilized a very low-fat diet.

Physical activity

Every immersion programme promoted physical activities, ranging from 1 h of structured physical education to 6 h of various activities. Activities ranged from daily walks to weight training, aerobic fitness and traditional sports play. Several programmes emphasized unstructured and lifestyle

Table 1 Immersion evaluation: programme and description of participants, duration, type, presence of comparison group and treatment provided

Study	*N* (% female)	Mean age in years (SD, range)	Type: duration	Control/comparison group?	Diet	Exercise	Nutrition/culinary education	Therapy	Follow-up? (length)
Adam *et al.* 2009 (40)	162 (58)	12.5 (1.35)	In-patient: 6 weeks (out-patient: 4 months)	Y – obese wait list ($N = 75$)	NR	NR	NR	NR	N
Barton *et al.* 2004 (24)	61 (63.9)	14.1 (0.2, NR)	Camp: mean 26 d	Y – normal weight ($N = 20$)	NR	NR	NR	Group	Y (4 months)
Braet 2006 (42)	122 (66)	12.7 (2.3, 7–17)	In-patient: 10 months	N	1400–1600 kcal d^{-1} 53% carbohydrate, 13.6% fat, 33% protein, 1.5 L water d^{-1}	10–14 h $week^{-1}$	NR	Group	Y (2 years)
Braet & Van Winckel 2000 (34)	36 (61)	11.9 (1.8, 7–17)	Camp: 10 d + CBT sessions one per month for 1-year post-intervention	Y – individual CBT ($N = 16$), group CBT ($N = 26$) and one-session advice group ($N = 47$)	1500 kcal d^{-1}	5 h d^{-1}	NR	Group	Y (3.6 years)
Boeck *et al.* 1993 (39)	21 (52.4)	14.2 (9.5–17.5)	In-patient: 8-month average stay (4 weeks, then trips home on weekends, holidays)	N	NR	Individualized exercise plans (unspecified)	1 per week	Individual and/or group, with behaviour modification programme	N
Cooper *et al.* 2006 (45)	2003: 74 (NR) 2004: 99 (NR) 2005: 89 (NR)	12.7 (2.3, NR) 13 (1.9, NR) 13.2 (1.8, NR)	Camp: mean 4.3 weeks	N	1700 kcal d^{-1}	Aerobic and resistance weight training (frequency unspecified)	Class 1 per week	Regular sessions	N
Deforche *et al.* 2005 (43)	47 (60)	13.4 (2.1, 9–16.5)	Residential: 10 months	N	1400–1600 kcal d^{-1}	2–2.5 h d^{-1}	NR	Group	Y (18 months)
Gately *et al.* 2005 (26)	185 (55.7)	13.9 (9–18)	Camp: 2–6 weeks (29 ± 11 d)	Y – overweight ($N = 38$) and normal weight ($N = 56$)	55% carbohydrate, 30% fat, 15% protein	6 h d^{-1}	Classes 4 per week	NR	N
Gately *et al.* 2000 (37)	194 (67.0)	12.6 (2.5)	Camp: 8 weeks	N	1400 kcal d^{-1}	5 × 1.5 h d^{-1}	Classes 2 per week	Psychoeducation parent weekend	Y (10 months)
Holt *et al.* 2005 (38)	15 (40)	13.65 (1.46, NA)	Camp: 6 weeks	N	NR	NR	NR	11-month aftercare support	N
Kirschenbaum *et al.* 2007 (35)	372 (310)	15.5	Camp: 4–8 weeks (mean 6)	N	<12 g fat d^{-1}	10K step $min\ d^{-1}$, with 5-h physical activity, 7/7 d $week^{-1}$	Nutrition/culinary class 2 d $week^{-1}$	CBT group and individual (2 per week each), parent weekend	Y (18 months)
	15 (46)	14.9	Residential: 30 weeks	N	<12 g fat d^{-1}	10K step $min\ d^{-1}$, with 3-h physical activity, 7/7 d $week^{-1}$	Nutrition/culinary class 2 d $week^{-1}$	CBT group and individual (2 per week each), parent weekends	Y (10 months)
Kirschenbaum *et al.* 2008 (36)	65 (68)	15.8	Residential: 24 weeks	N	<12 g fat d^{-1}	>10K step per day, with 3-h physical activity, 7/7 d $week^{-1}$	Nutrition/culinary class 2 d $week^{-1}$	CBT group and individual (4 × per week), parent weekends	Y (18 months)
Knöpfli 2008 (46)	130 (40)	13.8 (NR, 4–19)	In-patient: 8 weeks	N	1200–1600 kcal d^{-1}, 55–60% carbohydrate, 25–30% fat, 15–20% protein	6–8 h $week^{-1}$, plus free activities	Nutrition/culinary counselling 3.5 h $week^{-1}$ (including 0.5 h individual)	Behaviour modification individual session per week group sessions unspecified	N

Table 1 *Continued*

Study	*N* (% female)	Mean age in years (SD, range)	Type: duration	Control/comparison group?	Diet	Exercise	Nutrition/culinary education	Therapy	Follow-up? (length)
Larnkjaer 2008 (47)	*N* = 990 (54.5) (accum from 1994–2001)	12.3 (1.1, 10–14)	Residential: 60–90 d (mean 76)	N	1333–1380 kcal d^{-1}	Compulsory and voluntary; 3-m run in roughly .75 increments, 15- to 20-km walk and swim, 1 h of aerobics completed in 1 week	Nutrition education (frequency unspecified)	NR	N
McKenzie 1986 (41)	35 (0)	(8–18)	Camp: 4–6 weeks	N	1170 kcal d^{-1}, 37% carbohydrate, 41% fat, 22% protein	1-h physical education per day 6 d $week^{-1}$; weight training/conditioning class 1 per week, swimming 1 per week 2 elective classes, with free physical activities in evenings; weekend activities encouraged	Class 2 per week	Behavioural management group 2 per week	N
Quinlan *et al.* 2009 (48)	130 (70) (over 2 years)	12.8 (NR, 9–18)	Camp: mean 4.3 weeks	N	1800 kcal d^{-1}	5 h d^{-1}	Nutrition class 2 per week, cooking class 1 per week	Psychoeducation/ support groups 1 h $week^{-1}$	N
Regula 2007 (50)	174 (assumed 104 [NR])	(12–16)	In-patient: 24 d	N	1308 kcal d^{-1}, 56% carbohydrate, 26% fat, 18% protein	No estimate, but regularly performed exercises for total calorie expenditure of 2590	No specified time, but consultation available	No specified time, but consultation available	Y (6 months)
Rohrbacher 1973 (51)	204 (0)	(8–18)	Camp: 8 weeks	Y – internal camp attendees – overweight (not obese) (*N* = 11)	1200–1400 kcal d^{-1} 100 g protein d^{-1}	3 h d^{-1}	Informal meetings with nutritionist 1 per week	NR	Y (4 months)
Rolland-Cachera *et al.* 2004 (52)	121 (73.5)	(11–16)	In-patient: 9 months	N	Calorie restricted with gradual increase over 4 weeks: 1750–2200 kcal d^{-1}, 54% carbohydrate, 31% fat, 15% protein	14 h $week^{-1}$, divided into outdoor and indoor activities	NR	NR	Y (12–24 months)
Schwingshandl & Borkenstein 1995 (49)	41 (53.7)	11.8 (NR, 8.5–14.8)	Camp: 3 weeks	N	Kcal depended on %overweight, 50% carbohydrate, 30% fat, 20% protein	NR, but children were active in various summer sport activities	Dietary education, no time specified	NR	Y (4 months)
Van Vlierberghe *et al.* 2008 (44)	66 (66.6)	15.11 (1.15; 14–18)	In-patient: 10 months	N	1500 kcal d^{-1}	5 h d^{-1}	NR	Group	N
Walker *et al.* 2003 (25)	57 (57.9)	13.9	Camp: mean 4 weeks	Y – normal weight comparison (*N* = 38)	1300, 1800 or 2300 kcal d^{-1}	6 h d^{-1}	Nutrition, lifestyle and discussion groups 1 ea/week	NR, parent weekend	N

CBT, cognitive–behavioural therapy; N, no/absent; NR, details not reported; Y, yes/present.

activities (26,34–37). All programmes offered activities at least 6 d per week for the duration of immersion.

Nutrition/culinary education

Twelve of the 22 programmes (54.5%) offered formal instruction in nutrition and/or culinary techniques (26,35–37,39,41,45–49), with number of classes ranging from one to four per week. Two programmes (50,51) offered informal consultation as needed.

Therapy/support

About half of the programmes reviewed here included a clearly delineated CBT component. Some non-CBT programmes offered other therapeutic interventions (e.g. psychodynamic therapy, non-structured group support). We categorized an immersion treatment as including CBT if the intervention included regular group and/or individual meetings with a therapist utilizing CBT techniques for managing behaviour change, such as self-monitoring, motivational interviewing/decisional counselling and problem-solving.

Eleven of the 22 programmes (50%) included CBT(34–36,39–46). Eleven programmes either did not offer a CBT intervention (25,26,38,47,49–52) or offered a different kind of intervention (psychodynamic/analytic, general educational support) (24,37,48). Researchers did not consistently report number of hours spent in CBT or other therapies/support, but most reported one to two groups or individual meetings per week.

Family involvement

Three programmes (25,35,37) offered family weekends as opportunities for parents or other family members to learn the approach and experience immersion as their children lived it.

Weight change outcomes

Control and comparison groups

Six studies, three of which were performed by the same research group (24–26), used control or comparison groups to estimate their effectiveness. Two of these studies compared participants in immersion treatment with normal-weight comparison groups (24,25); one compared participants to both a normal-weight and an overweight comparison group (26); one study (34) used multiple overweight treatment groups for comparison; one study (51) used an internal comparison group of overweight but not obese participants, and one study (40) used an obese wait list control. Of these six studies, four (25,26,34,40) compared weight changes between the participant and comparison groups. All four studies found significantly greater decreases relative to comparison groups in percentage of body fat, fat mass (kg), BMI-SDS or waist-to-hip circumference measurements for participants in immersion treatment. It is important to note, however, that only one of these studies had randomly assigned participants to conditions (34), while the others used quasi-experimental designs. The authors of the study (34) with random assignment reported that the effect size for their summer camp was 0.67 vs. 0.25 for their primary comparison group.

Weight changes

Table 2 shows the specific changes in each programme on measures of weight for pre- vs. post-immersion. Table 3 presents the results for the 11 studies (34–37,43,49–52) that included follow-up evaluations (a 12th study included follow-up measures of psychosocial outcomes only (24)). Participants lost substantial amounts of weight in most of these studies, as measured by reductions in lb kg^{-1}, BMI and/or per cent-overweight. More specifically, participants averaged a reduction in per cent-overweight of 23.9% from pre- to post-immersion and 20.6% from pre-immersion to follow-up.

Considerable variability appeared in measures utilized, with some studies reporting weight change, others BMI, complicated algorithms of adjusted BMI and per cent-overweight. As other reviewers have noted (19), per cent-overweight has several advantages over other measures. First, in recent papers on obesity, this measure has become widely used (16,53). Second, it is relatively easy to understand. Finally, it is based on a metric that is easy to obtain and can be compared with established norms (54). We created approximate per cent-overweight means in studies that provided data on age, gender, height, weight and BMI, but did not calculate per cent-overweight. To do this, we used the following formula to calculate per cent-overweight:

$$\text{Per cent-overweight} = ([\text{Reported BMI}/50\text{th\%ile BMI}] - 1) \times 100$$

Fiftieth percentile BMI was calculated using Center for Disease Control BMI-for-age charts (54). We also used data provided in the studies on average age and gender to determine appropriate 50th%ile BMIs to use for comparison.

Follow-up weight change

Follow-up periods and measures varied greatly, contributing to the complexity of comparing programmes and outcomes. Follow-up periods ranged from 4 months to 3.6 years. Significant weight gain was found for participants in three programmes (37,43,52), with a small weight gain seen in three other studies (36,41,51) – one of much longer duration than the others (42). Three studies found continued weight loss between end of immersion experience and follow-up (35,50), with one study (35) reporting significant continued change in reduction in per cent-overweight from end of immersion to follow-up.

Table 2 Outcomes: pre- to post-immersion*

Publication	Weight change (kg)	Per cent-overweight (%)	BMI change
Adam *et al.* 2009 (40)	–4.0	–10.7	–2.2
Barton *et al.* 2004 (24)	–5.7	–11.3*	–2.2*
Braet 2006 (42)	–20.7	–42.9	–8.6
Braet & Van Winckel 2000 (34)	NR	–15.0	NR
Boeck *et al.* 1993 (39)	–25.8	–56.0*	–11
Cooper *et al.* 2006 (45) (2003, 2004 and	NR	–7.9	–2.6
2005 data reported separately)	NR	–8.7	–2.9
	NR	–8.3	–2.7
Deforche *et al.* 2005 (43)	–32.7	–54.0	–11.8
Gately *et al.* 2000 (37)	–10.8	–21.0*	–3.8
Gately *et al.* 2005 (26)	–6.0	–3.0	–2.3
Holt *et al.* 2005 (38)	–6.4	–12.9	–2.6*
Kirschenbaum *et al.* 2007 (35)			
Camps: (2004 and 2005, respectively)	–10.8	–15.4	NR
	–11.4	–18.0	NR
Residential	–38.6	–58.0	NR
Kirschenbaum *et al.* 2008 (36)	NR	–48.0	–10.6
Knöpfli 2008 (46)	–12.0	–4.9	–5.0
Larnkjaer 2008 (47)	–9.4	–20.9*	–3.7
Quinlan *et al.* 2009 (48)	–7.5	–16.3*	–2.9
McKenzie 1986 (41)	–9.5	–20.6	–3.6
Regula 2007 (50)	–3.8	–5.0	–1.4*
Rohrbacher 1973 (51)	–14.9	–30.0*	–5.5*
Rolland-Cachera *et al.* 2004 (52)	–30.3	–57.8*	–2.6
Schwingshandl & Borkenstein 1995 (49)	NR	–11.0	NR
Van Vlierberghe *et al.* 2008 (44)	–51.6*	–52.5*	–10.4*
Walker *et al.* 2003 (25)	–5.5	–10.8*	–2.1
Mean change	–15.7	–23.9	–4.5

*Estimated based on extraction from data reported.
BMI, body mass index; NR, Not reported and/or could not be calculated by authors based on data provided in study.

Attrition rates, when reported, ranged from 0% to 42%, with an average of 6.8% (34,39,42,45,52). In terms of participants lost to follow-up, rates appeared similar to those described for out-patient programmes by Wilfley *et al.* (4) with one exception: Schwingshandl and Borkenstein's (49) 4-month follow-up reported a dropout rate of 56.1%. More typical were Deforche *et al.*'s (43) rate of 14.6% at 1.5-year follow-up, and Rolland-Cachera *et al.*'s (52)and Gately *et al.*'s (37) rates of 18% and 21.5%, respectively. When participants were lost to follow-up, authors reported no significant differences between the non-participant group and those reporting follow-up information. Regula (50) and Rohrbacher (51) did not report follow-up participation rates.

Only Kirschenbaum *et al.* (36) used intent-to-treat analyses in its report of effectiveness. These researchers included 10 students who did not participate in their 1.5-year follow-up. They found that 44% of all students were successful in maintaining weight losses of 18 kg or more; without including the 10 non-participants as return to baseline failures, the success rate would have been 53%.

Correlates of success: cognitive–behavioural therapy vs. non-cognitive–behavioural therapy

Other than whether or not the programme included CBT, programmes appeared similar overall in activities and interventions: the average CBT programme ran longer (17.4 vs. 8.3 weeks), catered to a slightly older average age (13.8 vs. 13.2 years), used a diet with about the same average number of calories (kcal d^{-1} = 1467 CBT vs. 1562 non-CBT) and spent about the same time (3 h) in physical activity (3 h CBT vs. 3.75 non-CBT) and in nutrition/culinary instruction (1.9 sessions CBT vs. 2.2 non-CBT).

Differences in outcomes between CBT and non-CBT programmes appeared more substantial at follow-up (see Table 3 and Fig. 2). These CBT programmes that included follow-up seemed to outperform non-CBT follow-up programmes on average during intervention (–40.32% vs. –25.3%), between intervention and follow-up (+10.37% vs. +15.86%), and from pre-treatment to follow-up (–29.9% vs. –9.44%). The final row in Table 3 shows that the average change in per cent-overweight-favoured CBT immersion treatments in studies that included short- and

Table 3 Outcomes at follow-up: mean change in per cent-overweight in studies that included follow-up evaluations*†‡

Study	Change during experience (pre–post) (%)	Change during follow-up: short (<1 year)	Change during follow-up: medium (1–2 years)	Change during follow-up: long (>2 years)	Overall change (pre-immersion to FUP): short	Overall change (pre-immersion to FUP): medium	Overall change (pre-immersion to FUP): long
Braet 2006 (42)	–49.21*			+20.27*			–28.94*
Braet & Van Winckel 2000 (34)	–15.0*			+3.0*			–12.0*
Deforche *et al.* 2005 (43)	–54.0 (18)		+34.0 (19)			–20.0*	
Gately *et al.* 2000 (37)	–21.0*	+9*			–12.0*		
Kirschenbaum *et al.* 2007 (35)							
Camp	–16.7 (8)		–5.05 (19)			–21.75 (21)	
Residential	–59.0	–1.0			–60.0		
Kirschenbaum *et al.* 2008 (36)	–48.0 (28)		+11.0 (30)			–37.0 (33)	
Regula 2007 (50)	–6.7*	–1.4*			–8.1*		
Rohrbacher 1973 (51)	–30*	+5*			–25*		
Rolland-Cachera *et al.* 2004 (52)	–57.8*		+56.7*			–1.1*	
Schwingshandl & Borkenstein 1995 (49)	–11*	+10*			–1.0*		
Mean change	–33.5	+4.32	+24.16	+11.64	–21.22	–19.96	–20.47
Mean change by type							
CBT	–40.32	–1.0	+13.32	+11.64	–60	–26.25	–20.47
Non-CBT	–25.3	+5.65	+56.70	N/A	–11.53	–1.1	NA

*This number calculated based on formula: Per cent-overweight = ([Reported BMI/50th%ile BMI] – 1) × 100.

†Standard deviations reported where available.

‡Studies within the darker shaded areas included CBT; those in the white areas did not include CBT.

BMI, body mass index; CBT, cognitive–behavioural therapy; FUP, follow up.

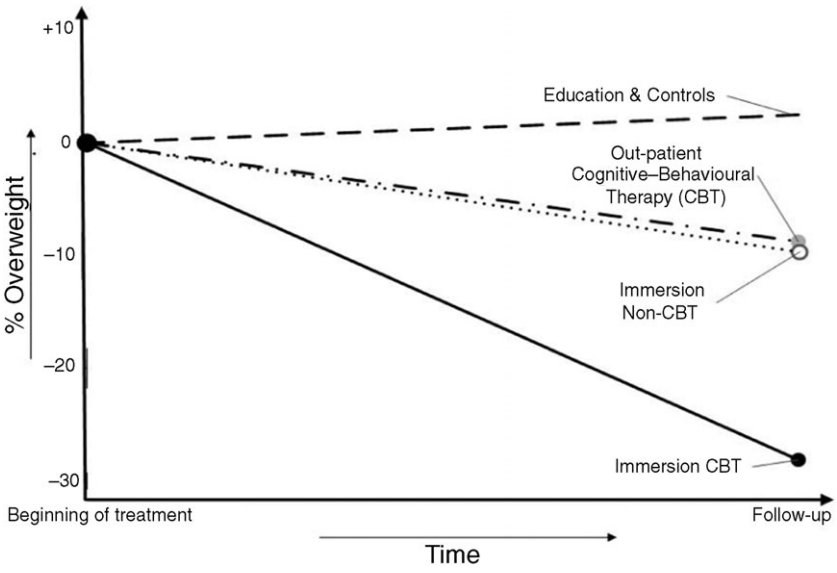

Figure 2 Average changes in per cent-overweight at follow-up for educational, out-patient cognitive–behavioural therapy (CBT), and immersion approaches to treatment of paediatric obesity.

medium-length follow-ups (none of the non-CBT studies included a long follow-up). A Fisher's exact probability test was used to determine the odds that all four comparisons were due to chance (four comparisons: change during follow-up for short and medium follow-ups, respectively; change pre-immersion to follow-up for short and medium follow-ups, respectively). The result (Fisher's test [$n = 4$], $P = 0.01$) suggests that the greater reductions in per cent-overweight observed for the CBT immersion programmes was probably not due to chance.

Although the differences in these outcomes are striking, aspects other than CBT may have contributed to these differences. For example, participants generally stayed in CBT immersion programmes for longer durations than non-CBT programmes (Ms = 17.4 vs. 8.3 weeks). The CBT programmes also included notably longer follow-up intervals, which would have been expected to decrease the magnitude of change observed in follow-ups (Ms = 93.2 vs. 22.8 weeks).

Additional correlates of success

Table 4 presents correlates of success other than CBT. Five studies (35,41,45,47,49) indicated that longer stays were associated with better outcomes. Four studies (43,46–48) reported that boys generally lost more weight than girls during treatment. However, none of the follow-up studies reported better outcomes for either gender.

Some variables indicated as correlates of success showed contradictory findings across studies. Four studies credited age as a predictor of overall success in their immersion programme, but three (43,44,48) reported younger participants as more successful, while one (38) found that older participants fared better. Baseline BMI and weight were also noted as significant factors for success, with three studies (44,45,48) indicating better outcomes for heavier participants and two others (38,43) indicating greater success by less overweight participants.

Psychosocial outcomes

Table 5 shows changes in psychosocial variables. Decreased anxiety concerning physical abilities and body issues after camp (24,38) and increases in overall body/self-image (48,51), quality of life (40,45,48), general self-esteem and self-efficacy (40,41,48,51) post-immersion were found. Furthermore, some studies reported that such benefits extended beyond the immersion environment; Braet's (42) 3.6-year follow-up found that participants maintained significant decreases in general psychopathology and eating disorder symptoms ($P < 0.05$), as well as increases in global self-worth ($P < 0.001$).

Discussion

This review attempted to describe the results for all published studies on immersion treatment for childhood and adolescent obesity. Participants in the 22 studies that met inclusion criteria decreased their per cent-overweight by an average of 23.9% during treatment and by 20.6% at follow-up. In comparison, Wilfley *et al.*'s (4) meta-analysis of out-patient programmes targeting lifestyle changes showed reductions in per cent-overweight of 8.2% during treatment and 8.9% at follow-up. The 191% ostensible advantage of immersion vs. out-patient treatment at post-treatment and 130% at follow-up argues for additional discussion and further studies, especially randomized controlled trials and observational studies of immersion vs. other treatment modalities.

Table 4 Correlates of success: items of noted significant association in promoting successful change*

Duration of stay	Age	Baseline BMI/weight values	Gender	Initial weight loss
Cooper *et al.* 2006 (45) Kirschenbaum *et al.* 2007 (35)	Braet 2006 (42) (younger) Deforche *et al.* 2005 (43) (younger)	Braet 2006 (42) (lighter) Deforche *et al.* 2005 (43) (heavier)	Deforche *et al.* 2005 (43) (male) Knöpfli 2008 (46) (male)	Braet 2006 (42) Schwingshandl & Borkenstein 1995 (49) (increased lean BMI)
Larnkjaer 2008 (47) McKenzie 1986 (41) Quinlan *et al.* 2009 (48)	Kirschenbaum *et al.* 2007 (35) (older) Larnkjaer 2008 (47) (younger)	Kirschenbaum *et al.* 2007 (35) (lighter) Larnkjaer 2008 (47) (heavier) Van Vlierberghe *et al.* 2008 (44) (heavier)	Larnkjaer 2008 (47) (male) Quinlan *et al.* 2009 (48) (male)	

*Successful in promoting change in weight, BMI, percentage of body fat, fat mass, waist circumference, hip circumference, oxygen intake or activity levels.
BMI, body mass index.

Table 5 Psychosocial changes during immersion treatment

Athletic competence	Anxiety/worries	Body image	Psychological well-being	Eating pathology/ED	General psychopathology	Global self-worth	Quality of life	Self-esteem/efficacy
↑ Deforche *et al.* 2005 (43)	↓ Barton *et al.* 2004 (24) ↓ Holt *et al.* 2005 (38)	↑ Adam *et al.* 2009 (40) ↑ Quinlan *et al.* 2009 (48) ↑ Rohrbacher 1973 (51)	↑ Barton *et al.* 2004 (24)	↓ Barton *et al.* 2004 (24) ↓ Braet 2006 (42)	↓ Braet 2006 (42)	↑ Adam *et al.* 2009 (40) ↑ Barton *et al.* 2004 (24) ↑ Braet 2006 (42)	↑ Adam *et al.* 2009 (40) ↑ Knöpfli 2008 (46) ↑ Quinlan *et al.* 2009 (48)	↑ Deforche *et al.* 2005 (43) ↑ Quinlan *et al.* 2009 (48)

↑ indicates increase in variable. ↓ indicates decrease in variable.

In addition to substantial weight changes, immersion studies generally reported notably lower rates of attrition (averaging 6.8%) vs. those typically reported for out-patient treatment (e.g. 19.7% (4)). Even though the studies reviewed here varied greatly in terms of length and measured changes, the lack of attrition has important implications. In the long run, if immersion treatment reduces attrition, it could certainly prove beneficial for that reason alone. Prior research makes it clear that poorer performance during treatment increases attrition (22) and that failure to continue treatment decreases the probability of change over time (23).

Prior meta-analyses (4,18) and qualitative analyses (19) make it clear that CBT has favourable short- and long-term effects relative to educational and control comparison groups. This review also showed that including CBT in this intensive intervention seemed to lead to better outcomes. Furthermore, follow-ups in the CBT studies were generally longer than those in the non-CBT studies that included follow-ups. Even though longer follow-ups are almost invariably associated with relatively poorer outcomes (4), the CBT immersion treatments seemed to outperform the non-CBT interventions by a wide margin.

Cognitive–behavioural therapy may prove quite useful in immersion treatments because it helps to develop and reinforce key self-regulatory skills, such as self-monitoring (55–58). It also can reduce negative emotional states and improve psychosocial functioning (24,25,38). While the observed effects in this review are based on comparisons across studies that varied on several dimensions (i.e. longer duration of immersion for those in CBT vs. non-CBT programmes), the weight of the evidence here and in previous studies that were not focused on immersion treatments appears to support the value of incorporating CBT in immersion treatment.

Numerous studies also show that relatively rapid weight losses in the context of CBT generally predict better long-term outcomes (27,28,59). Early success may, in turn, improve self-efficacy and other positive internal reactions (e.g. improvements in moods) (24–27). Improvements in self-efficacy, attitudes and moods could translate to greater commitment to maintain change and improve weight loss. In other words, both overweight children and their families involved in CBT immersion treatment could use the rapid and consistent weight losses the children experience as proof that 'I can do this! I can really lose this weight!' CBT could help the children and parents accentuate this positive experience by seeing the connection between their behaviours (e.g. self-monitoring, goal setting, planning) and these favourable outcomes, thereby enhancing self-efficacy and long-term commitment. Perhaps this analysis helps explain the seemingly substantial improvements in results associated with including CBT in immersion treatments.

Limitations in this review include reliance on evaluation research that was conducted in real world settings with attendant difficulties in obtaining verified measures of heights and weights at follow-up in some cases, limited numbers of follow-ups and related problems. In addition, treatments varied substantially across such potentially key dimensions as diet, frequency of CBT sessions, involvement of parents directly and follow-up protocols. The lack of standard protocols and randomized controlled trials in this area means two things. First, it points to the difficulties inherent in standardizing protocols in applied research. Second, it makes drawing conclusions tenuous because of the lack of controls for many variables and inconsistencies in both independent and dependent variables. Also, statistical power was inadequate in many cases.

Furthermore, the authors could evaluate only English language articles. We found two non-English programmes (60,61) that we could not obtain or translate; omitting such studies may have reduced our understanding of the impact of immersion treatments.

Another concern pertains to the relative absence of intent-to-treat analyses in these studies (and in follow-ups involving treatments for obesity more generally). Current standards for such analyses require researchers to consider all dropouts as treatment failures, in accord with studies that show minimal improvements without effective intervention (4,19,22,62). Failing to include such analyses undoubtedly inflates success rates by creating 'best case scenarios (63)'.

Future research on immersion treatments could include direct comparisons with out-patient treatments, varying only modality of treatment. The potential value of such randomized controlled studies seems clear. Studies could also control for such factors as inclusion of CBT, type of diet and degree of parental involvement. In accord with recent expert recommendations (13,14), this review indicates that immersion treatment including CBT deserves consideration as an important treatment option by health-care providers and families. Further studies will undoubtedly help elucidate active mechanisms of change and determine if the promise suggested in the present review remains as compelling after closer scrutiny.

Conflict of Interest Statement

Both authors are current employees of Wellspring, a division of CRC Health Group, a leading provider of immersion treatment for children and adolescents.

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