

Obesity Management

A review of electronic interventions for prevention and treatment of overweight and obesity in young people

B. Nguyen, K. P. Kornman and L. A. Baur

University of Sydney Clinical School, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

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Address for correspondence: Ms B Nguyen, University of Sydney Clinical School, The Children's Hospital at Westmead, Locked Bag 4001, Westmead, NSW 2145, Australia.
E-mail: thanhn@chw.edu.au

Summary

The objective of this systematic review is to provide a qualitative comparison of interactive electronic media interventions for the prevention or treatment of obesity and/or obesity-related behaviours in children and adolescents. Literature searches of 12 databases from the earliest publication date until March 2010 were conducted. Twenty-four studies in which children and/or adolescents interacted with electronic interventions delivered as adjunct or sole interventions for the prevention or treatment of obesity and/or obesity-related behaviours met the inclusion criteria. Fifteen focussed on obesity prevention and nine on treatment interventions. The average study quality design score was 45%. Most studies demonstrated some form of significant outcome (e.g. reported changes in dietary and/or physical activity behaviours) in participants receiving interactive electronic interventions, with 11 out of 15 studies leading to positive changes in measured or reported adiposity outcomes. In 87% of studies, the effects of interactive electronic interventions were not separately evaluated from other intervention components. These results should be viewed with caution because of the overall poor quality of the studies. Studies were mostly conducted in the USA, largely in minority populations, and the direct transferability of interventions to other populations is unclear. Further high quality research is needed in this area to accurately inform the evidence base.

Keywords: Adolescent, child, electronic interventions, obesity.

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Introduction

The global prevalence of child and adolescent obesity is increasing (1), with obesity now one of the most common chronic disorders in this age group (2). There is no universally effective approach to the prevention and treatment of obesity in young people (3,4). Comprehensive programmes, involving dietary and physical activity change along with environmental modification may assist in the prevention of obesity in children and adolescents (3), while lifestyle treatment programmes, including family-targeted

interventions involving parents, have been effective in reducing the level of child and adolescent obesity at 6 and 12 months (4).

Recent advances in technology provide the opportunity to use youth-friendly and interactive modes of communication such as electronic media in both obesity management and prevention interventions. Benefits of interactive electronic interventions include availability of electronic technology to youth in both school and non-school settings, popular use among youth, incorporation of rich media, immediate and often tailored feedback, flexible

programme access, cost effectiveness, the potential for wide programme reach and the ability to serve as an adjunct or stand alone programme (5). Interventions featuring interactive electronic media are increasingly being developed and evaluated. Therefore, the potential application of interactive electronic interventions in the prevention or treatment of obesity in young people warrants further investigation.

Two reviews have previously examined the use of innovative technologies on weight management outcomes in children and adolescents, both indicating that while electronic interventions show potential there is a need for further research in this area (5,6). These reviews were limited to randomized control trials (RCTs) (5,6) and quasi-experimental studies (5) and examined Internet (6) and compact disc read-only memory (CD-ROM) (5) interventions only. The present systematic review differs from these two previous reviews in that it extends to studies conducted outside of the USA, other study designs, all types of interactive electronic interventions addressing obesity and/or obesity-related behaviours, a variety of study settings and clearly delineates interventions focussed on obesity prevention or treatment, children and/or adolescents. The effectiveness of Web-based interventions in achieving weight loss and maintenance in overweight adults has also been reviewed. However, determination of intervention effectiveness was not possible because of the small number of comparable studies (7).

The objective of this systematic review is to provide a comparative evaluation of interactive electronic media interventions for the prevention or treatment of obesity and/or obesity-related behaviours in children and adolescents. Electronic interventions included in this review required participant interaction with the electronic technology as an adjunct or stand alone programme and were delivered via computer-based programmes, Internet sites, electronic messaging systems, emails, social networking media, e-whiteboards or related media.

Methods

Search strategy

Systematic literature searches were performed using 12 electronic databases: Medline, Embase, PsycINFO, Web of Science, Scopus, ERIC, All EBM Reviews (Cochrane DSR, ACP Journal Club, DARE, CCTR, CLEED, CLCMR and CLHTA), A+ Education, Australian Public Affairs Full Text, Linguistics and Language Behavior Abstracts, ProQuest Education journals and CBCA Education, Sport Discus.

As interventions involving interactive electronic media were expected to be recent, databases were searched for literature from the earliest publication date until March

2010. Numerous search terms were employed to denote interactive electronic media (e.g. communications media, Internet, electronic mail, multimedia, electronic media, web, online, email, social networking, social networking media, computer-mediated communications), prevention (e.g. prevention, prevention study, intervention, intervention studies, primary prevention, health promotion), treatment (e.g. treatment, intervention, management, weight management, therapy, therapeutics), overweight and obesity (e.g. obesity, overweight, body weight, weight), and children and adolescents (e.g. adolescent, child, children, pediatric, paediatric, teen, youth).

In addition, reference lists from obtained articles were scanned for potentially relevant articles, websites cited in relevant articles were viewed and relevant national health websites searched for 'grey literature'.

Selection criteria

English language research publications were identified from peer-reviewed literature, 'grey literature', book chapters and dissertations. Studies with interactive electronic interventions delivered as either adjunct or sole interventions for the prevention or treatment of obesity and/or obesity-related behaviours in children and/or adolescents (up to 18 years of age) were included. Interactive electronic interventions were defined as those requiring participant interaction (e.g. following prompts, entering information, completing online tasks, receiving automated feedback) with the electronic technology and which were delivered via computer-based programmes, interactive Internet sites, electronic messaging systems, emails, social networking media (e.g. Facebook), e-whiteboards or related media.

Interventions targeting nutrition, physical activity and/or behavioural therapy without any restriction on the type of study design (RCTs, non-RCTs, longitudinal studies, quasi-experimental studies, pre-post studies), setting (school-, community- and/or clinic-based) or provider of the intervention, and which assessed change in either knowledge, mediators, behaviours and/or in physical status as outcomes were included.

Citation titles and abstracts were screened by two researchers for relevance to the review using the above-mentioned selection criteria. Full text articles of potentially eligible citations were obtained and assessed using the selection criteria. Both researchers agreed on retrieved studies that were included for review.

Critical appraisal and data synthesis

In order to evaluate the quality and strength of evidence, the same two researchers appraised selected studies according to specific criteria. A quality assessment checklist was developed based on critical appraisal guides available from

the Cochrane Collaboration website (8,9) and addressed questions relating to nine domains: true randomization (for RCTs only), allocation concealment, blinding, baseline comparability, follow-up, accurate reporting of outcomes, intention-to-treat analysis, validation of tools and separation of the e-intervention effects from other intervention components. RCTs and non-RCTs were rated on each of these nine domains and allocated a study quality score equal to the percentage of the maximum obtainable score. Non-RCTs differed from RCTs in that participants were not randomly allocated to groups. Other intervention studies, such as longitudinal studies and pre-post studies, were assessed using questions adapted from the *CASP Appraisal Checklist* tool (10). Study quality coding criteria and tabulated scores are provided in Tables 1 and 2.

Only a qualitative analysis of included studies was undertaken because of the heterogeneity of studies relating to methodology, intervention and outcomes. Data were extracted using a standard form developed by the researchers (see Tables 3 and 4). Studies were described in terms of their design, sample characteristics, inclusion of a comparison group, parental involvement, outcomes, interactive electronic intervention (type, content, duration, stand alone or adjunct programme), incentives and programme use. Based on extracted data and critical appraisal assessments, a comparative narrative summary of included studies is provided. Any differences between researchers were resolved by discussion.

Results

Description of included studies

The literature search recovered 1856 citations of which 1832 were not considered to be relevant to the review (Fig. 1). Twenty-four articles relating to 21 separate interventions met the inclusion criteria. All included studies were published between 1998 and 2008. Out of the 24 articles, fifteen focussed on obesity prevention (three in children (11–13) and twelve in adolescents (14–25)), and nine focussed on treatment interventions (one in children (26) and eight in adolescents (27–34)). Fifteen studies reported adiposity outcomes at both baseline and follow-up (11,13,15,17–20,26,27,29–34) with body mass index (BMI) z-scores assessed in eight studies (13,17,18,20,26, 28,29,31). Nineteen studies examined dietary intake and/or amount of physical activity (11–15,17–21,23–28,32–34), six investigated weight-related concerns or behaviours (20,22,28–30,34) and seven assessed psychosocial measures (12,13,15,21,23,30,34). Interactive electronic interventions delivered as stand alone (12,20,23,26,28,29) or adjunct (11,14,16–18,21,22,24,25,27,30–34) programmes included: CD-ROM (13,15,17,18), Internet and emails (27–29,32–34), Internet only (11,12,14,16,19–

26,30) and telemedicine (31) technologies. Seven interventions included some form of parental involvement (11,13,17,18,26,27,29,32–34) with five interventions featuring an interactive Internet- or CD-ROM-based component for parents (11,17,18,26,27,32–34). The theoretical basis underlying most interventions related to social cognitive theory (35) or the transtheoretical model (36).

Overall, the interventions involved 5812 young participants with an equal distribution of males and females. Out of the 21 interventions, 11 were described as RCTs (11,13,17–20,23,26–29,32–34), five as non-RCTs (14–16,24,25) and five involved other study designs (12,21,22,30,31). Eight out of the 21 interventions were based on ethnically diverse samples (13–16,21,23,26,28), four comprised African-Americans only (11,12,27,32–34), four included a majority of Caucasian participants (19,20,22,29), one involved Taiwanese participants only (30), and four did not describe participants' ethnicity (17,18,24,25,31). The majority (86%) of interventions were conducted in the USA (11–16,19–21,23,24,26–29,32–34), one was conducted in Germany (31), one in Belgium (17,18) and one in Taiwan (30). The duration of the interventions varied from 2 weeks to 2 years with 14 interventions lasting 16 weeks or less (11–13,15,16,19–21,23,24,26,28–30), two delivered over 6 months (27,32–34), two over 1 year (14,31), one lasting 2 years (17,18) and two being of unknown duration (22,25). One-third of all studies provided monetary (11,12,16,23,27–29,34) or non-monetary incentives (19,30,32,33) to participants and attrition averaged 19% in studies where it could be determined (12,13,15,16,19,20,22,23,26–30,32–34). Programme use was variable among the nine studies in which it was measured (11,12,19,20,27,29,32–34).

Quality of included studies

The study design quality coding criteria and appraisal for each intervention are outlined in Tables 1 and 2. No studies fulfilled all design quality requirements. Two studies met 88% of the requirements (20,28). Overall, the average study design quality score was 45% for all interventions; 42% for RCTs and non-RCTs (39% and 37% for prevention interventions in children and adolescents, respectively, 13% for treatment interventions in children, and 66% for treatment interventions in adolescents) and 61% for other intervention studies (71% for prevention interventions in children and 57% for treatment interventions in adolescents). Most studies (87%) did not separate the effects of the electronic intervention from other intervention components (11,13,14,16–19,21,22,24,27,31–34). Four of the 11 RCTs were not truly randomized or failed to adequately describe the randomization method (13,17,19,26). Details of allocation concealment (11,13–17,19–23,26–29,32–34), study blinding (11,13–17,22,26,32,33),

Table 1 Study quality coding criteria and appraisal (RCTs and non-RCTs)

Study	True randomization	Allocation concealment	Blinding	Baseline comparability	Follow-up	Accurate outcome reporting	ITT analysis	Tool validation	Separation of e-intervention effects	Score (% of maximum)
Child overweight and obesity prevention interventions										
Goran <i>et al.</i> (13)	No	Unknown	Unknown	Yes	Yes	Yes	Yes	Unknown	No	44%
Baranowski <i>et al.</i> (11)	Yes	Unknown	Unknown	No	Unknown	Yes	Yes	Unknown	No	33%
Adolescent overweight and obesity prevention interventions										
Jones <i>et al.</i> (20)	Yes	Unknown	Yes	Yes	Yes	Yes	Yes	Yes	N/A	88%
Casazza <i>et al.</i> (15)	N/A	Unknown	Unknown	No	Yes	Yes	Unknown	Yes	Yes	50%
Haerens <i>et al.</i> (17,18)	Unknown	Unknown	Unknown	Unknown	Yes	Yes	No	Yes	No	33%
Jago <i>et al.</i> (19)	Unknown	Unknown	No	No	Unknown	Yes	Yes	Yes	No	33%
Marks <i>et al.</i> (23)	Yes	Unknown	No	Unknown	Yes	Yes	Unknown	Yes	N/A	50%
Frenn <i>et al.</i> (16)	N/A	Unknown	Unknown	Yes	No	Yes	No	Yes	No	38%
Luce <i>et al.</i> (22)	N/A	Unknown	Unknown	Unknown	Unknown	Yes	No	Yes	No	25%
Long <i>et al.</i> (21)	N/A	Unknown	No	Unknown	Unknown	Yes	Unknown	Yes	No	25%
Frenn <i>et al.</i> (14)	N/A	Unknown	Unknown	Unknown	No	Yes	No	Yes	No	25%
Winnett <i>et al.</i> (25)	N/A	No	No	Unknown	Unknown	Yes	Unknown	No	Yes	25%
Russ <i>et al.</i> (24)	N/A	No	No	No	Unknown	Yes	Unknown	No	No	13%
Child overweight and obesity treatment interventions										
Moore (26)	Unknown	Unknown	Unknown	Unknown	Unknown	Yes	Unknown	Unknown	N/A	13%
Adolescent overweight and obesity treatment interventions										
Doyle <i>et al.</i> (29)	Yes	Unknown	Yes	No	Unknown	Yes	Yes	Yes	N/A	63%
Williamson <i>et al.</i> (27,34)	Yes	Unknown	No	Unknown	Yes	Yes	Yes	Yes	No	56%
Celio (28)	Yes	Unknown	Yes	Yes	Yes	Yes	Yes	Yes	N/A	88%
White <i>et al.</i> (32,33)	Yes	Unknown	Unknown	Yes	Unknown	Yes	Yes	Yes	No	56%

ITT, intention-to-treat analysis; N/A, not applicable; RCTs, randomized controlled trials.

Table 2 Study quality coding criteria and appraisal (other intervention studies)

Study	Clear aims	Selection criteria provided	Adequate control group	Appropriate tables and graphs	Appropriate statistical methods	Adequate support of conclusions	Result applicability to local population	Consideration of all outcomes	Separation of e-intervention effects	Score (% of maximum)
Child overweight and obesity prevention interventions										
Thompson <i>et al.</i> (12)	Yes	Yes	N/A	Yes	Yes	Yes	No	No	N/A	71%
Adolescent overweight and obesity treatment interventions										
Hung <i>et al.</i> (30)	Yes	Yes	N/A	Yes	Yes	Yes	Unknown	Yes	No	75%
Schiell <i>et al.</i> (31)	Yes	No	N/A	Yes	Unknown	Yes	Unknown	Unknown	No	38%

N/A, not applicable.

baseline comparability (14,17,21–23,25–27,34), follow-up (11,19,21,22,24–26,29,32,33) and analysis (15,21,23–26) were not adequately reported for most studies. All RCTs and non-RCTs accurately reported outcomes and the majority used validated measurement tools (14–17,19–23,27–29,32–34).

Child studies

Prevention

Three US studies, including two RCTs (11,12) and one pre–post study (13), featured short-term interventions targeting obesity prevention in children aged 8–11 years (Table 3). Study sample sizes ranged from 35 girls (11) to 209 boys and girls (13).

Two of the studies assessed the impact of an 8-week home Internet programme on dietary and physical activity measures in African–American girls (11,12). One of these two studies included separate Internet programmes for participants’ parents. This pilot RCT lacked statistical power to detect any significant effects of a combined summer day camp and home Internet programme on BMI, physical activity or dietary measures (11). Findings from the larger pre–post pilot study suggest that a stand alone home Internet programme can lead to significant improvements in dietary and physical activity behaviours in African–American girls at risk of obesity and higher participant log-on rates (12). However, this study lacked a control group and did not measure adiposity.

The third study, a CD-ROM-based RCT intervention supplemented by classroom and family-based homework assignments improved obesity indices (mean BMI z-score reduction: 0.07) and produced subtle changes in physical activity in girls only (13).

Treatment

Only one treatment intervention for children met the inclusion criteria. This US feasibility RCT compared a home Internet behavioural programme with a control website in 30 families with an at-risk or overweight 6- to 12-year-old child (26) (Table 4). After 6 weeks, this underpowered and poor quality (quality score: 13%) intervention reported stability in BMI z-scores without clear treatment effects and modest improvements in health promotion behaviour.

Adolescent studies

Prevention

Twelve studies targeted obesity prevention in adolescents (14–25) (Table 3). All but two (17,18) were conducted in the USA and five were RCTs (17–20,23). Interventions lasted between 2 weeks to 2 years with ethnically diverse sample populations ranging from 41 to 2840 participants aged 11–18 years. Interactive electronic interventions

Table 3 Summary of child and adolescent obesity prevention interactive electronic interventions

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Child overweight and obesity prevention interventions Thompson <i>et al.</i> (12)	Pre-post pilot study Home-based Houston, Texas, USA	<i>n</i> = 80; ages 8–10; 100% females; 100% African-American; BMI \geq 50th percentile for age and sex Final analysis: <i>n</i> = 73 Attrition: 9%	None	None	Baseline and 8 weeks: self-reported fruit, 100% fruit juice and vegetable consumption, self-reported physical activity, self-efficacy (for diet and physical activity) and programme usage (weekly log-on rate) Adiposity measures: none	Technology: Internet (stand alone) Duration: 8 weeks Weekly modules (~20 min per week) featuring role modelling comics, problem solving, goal setting and review Incentive: weekly incentive worth \$US5 for completion of activities	Significant improvements in self-reported fruit, fruit juice, and vegetable consumption, dietary self-efficacy, and physical activity No significant difference in physical activity self-efficacy Programme use: 74.5% average weekly participant log-on rate
Goran <i>et al.</i> (13)	RCT Schools randomized to treatment (two schools) or control (two schools) School-based West Covina, Los Angeles, USA	<i>n</i> = 209; 4th graders; ages 8.8–11.1; mean age = 9.5; 51% females; 58% Hispanic Final analysis: <i>n</i> = 122 Attrition: 42%	Two schools received educational CD-ROMs not related to health topics	Family homework assignments (not detailed)	Baseline and 8 weeks: height, weight, body fat (bioimpedance analysis), BMI, physical activity (accelerometer) and self-reported psychosocial measures related to physical activity (self-efficacy, social norms and outcome expectancies) Adiposity measures: weight, BMI, BMI z-score	Technology: Interactive CD-ROM game (not stand alone) Duration: 8 weeks Two schools received 12 h of intervention: 8 CD-ROM interactive lessons (45 min per lesson) based on social cognitive theory, supplemented by four classroom and four homework assignments (45 min per assignment) Incentive: N/A	Significant obesity reduction (adjusted mean reductions of 0.07 for BMI z-score and 1.4% for percentage of body fat) in treatment girls only Significant increase in light intensity physical activity in treatment girls only (reduction in boys); decrease in moderate intensity physical activity for both genders; but no significant difference in total physical activity Marginal significant treatment effects on behavioural outcomes related to physical activity Programme use: N/A
Baranowski <i>et al.</i> (11)	Pilot RCT Girls randomized to treatment (<i>n</i> = 19) or control (<i>n</i> = 16) Summer day camp-based and home-based Houston, Texas, USA	<i>n</i> = 35; age 8; 100% females; 100% African-American; BMI \geq 50th percentile for age and sex; parents/carers involved Final analysis: <i>n</i> = 35 (intention-to-treat approach) Attrition: not mentioned	4-week summer day camp (usual camp activities) for girls followed by separate monthly home Internet programmes for girls and their parents/carers featuring links to general health and homework websites	Separate home Internet programmes for parents/carers within each group Parents in the treatment group exposed to educational lunch campaign during camp period and encouraged by their daughters to participate in physical activity and increase availability of fruit, fruit juice and vegetables at home	Baseline and 12 weeks: BMI, self-reported consumption of fruit, 100% fruit juice and vegetables, physical activity (accelerometer and questionnaire) and programme usage (weekly/monthly participant log-on rate) Adiposity measures: BMI	Technology: Internet (not stand alone) Duration: 12 weeks 4-week summer day camp (usual camp activities and programme specific activities) followed by separate 8-week home Internet programmes for girls and their parents/carers Girls: weekly Internet programme including role modelling comics, problem-solving, goal setting and review; weekly email and telephone reminders to log on to their website Parents: weekly Internet programme included a role model parent character who commented on the girls' comic strips, a parent poll on best ways to encourage lifestyle changes, parent goal setting to support their daughters with their goals and review of their daughters' goal attainment Incentives: \$US10 (girls) and \$US25 (adults) for completion of all assessments; regular \$US100 lottery in each group	No significant changes in BMI, physical activity or fruit, vegetable and water consumption in the treatment group compared to the control group The pilot study was underpowered but favourable trends were observed in dietary measures Programme use: 48% of girls and 47% of parents overall weekly log-on rates

Table 3 Continued

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Jones <i>et al.</i> (20)	Adolescent overweight and obesity prevention interventions RCT Stratified by school; students from two schools randomized to treatment (n = 52) or wait list control (n = 53) Home-based Idaho & California, USA	n = 105; 9th–12th graders; mean age = 15.1; 65% males; 64% Caucasian; ≥85% percentile for age-adjusted BMI Final analysis: n = 87 Attrition: 17%	Wait list control offered an online or printed version of the programme at 9 months	None	Baseline, 16 weeks and 9 months: height, weight (self-reported at 16 weeks), BMI, BMI z-score, self-reported dietary fat and sugar intake, depressed mood, binge eating behaviour, and programme usage (average number of content screens accessed per week) Adiposity measures: weight, BMI, BMI z-score	Technology: Internet (stand alone) Duration: 16 weeks Weekly psycho-educational and behavioural interactive Internet intervention and asynchronous discussion group facilitated by a research assistant; weekly reminder letters and occasional motivational letters Incentive: N/A	Significant reductions in BMI (mean change: 0.7 kg m ⁻²) and BMI z-score (mean change: 0.18) in intervention group at 9 months Significant reductions in objective and subjective binge episodes and weight and shape concerns in the intervention group post-treatment and at 9 months No significant changes in dietary fat and sugar intake or depression Programme use: 27% of treatment participants accessed the programme for ≥8 weeks
Casazza <i>et al.</i> (15)	Non-RCT Three selected schools (control, traditional education, computer education) School-based Florida, USA	n = 311; 9th–12th graders; ages 13–18; mean age = 15.8; 66% females; 52% non-Hispanic African-Americans Final analysis: n = 275 Attrition: 12%	One control school receiving traditional education; lectures and pamphlets; five 45-min sessions	None	Baseline and 16 weeks: BMI, self-reported nutrition knowledge, dietary habits, physical activity knowledge, self-efficacy for diet and physical activity and social support Adiposity measures: BMI	Technology: CD-ROM (stand alone) Duration: 16 weeks Computer intervention: educational CD-ROM; five 45-min sessions Incentive: N/A	The computer intervention group reduced their BMI by 0.2 kg m ⁻² and improved their nutrition knowledge, physical activity, self-efficacy, social support, and decreased dietary fat and meals skipped The traditional education group improved their nutrition knowledge, social support and self-efficacy only Programme use: N/A
Haerens <i>et al.</i> (17,18)	Cluster RCT Random sample of schools randomized to intervention alone (five schools; n = 1006), with parental support (five schools; n = 1226) or control (five schools; n = 759) School-based West Flanders, Belgium	15 schools; n = 2840; 7th–8th graders; ages 11–15; mean age = 13.1; 63% males; ethnicity not detailed Final analysis: n = 2287 Attrition: 25%	Five control schools	Intervention group with parental involvement: healthy eating and physical activity education via an interactive school meeting (five schools only), school newsletters (three times per year) and a free CD-ROM with the adult computer-tailored intervention (first year only)	Baseline, 1 year and 2 years: Weight, height, BMI, BMI z-score, self-reported physical activity (and assessed by accelerometers in a sub-sample) and dietary intake (fat, fruit, water and soft drinks) Adiposity measures: weight, BMI, BMI z-score	Technology: CD-ROM (not stand alone) Duration: 2 years Intervention alone: healthy eating and physical activity promotion in school, individual physical fitness test during the second year and a CD-ROM class intervention providing tailored feedback for physical activity and fat and fruit intake (once per year) Intervention with parents: healthy eating and physical activity information via school newsletters and a CD-ROM with the adult computer-tailored intervention Incentive: N/A	In girls, BMI and BMI z-score increased significantly less in the intervention group with parental support (BMI increase: 0.22 and 0.55 kg m ⁻² ; BMI z-score increase: 0.07 and 0.17 after 1 and 2 years) compared with the control or intervention alone groups No significant positive intervention effects on body mass were found in boys At 1 and 2 years, significant positive effects on physical activity (including from accelerometer data) in both genders and on fat intake in girls were observed Parental involvement helped decrease fat intake in girls at 1 year only No significant positive intervention effects were found on fruit, soft drink and water consumption Programme use: N/A

Table 3 Continued

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Jago <i>et al.</i> (19)	Cluster RCT Spring (16 troops) and fall (26 troops) cohorts randomized to treatment (21 troops; <i>n</i> = 240) or control (21 troops; <i>n</i> = 233) Community- (troop meetings) based and home-based Texas, USA	42 troops; <i>n</i> = 473; boy scouts; ages: 10–14; mean age = 13; 100% males; 74% Caucasian Final analysis: <i>n</i> = 473 Attrition: 0%	Control group received a 9-week 'mirror image' fruit and vegetable intervention	None	Baseline, 9 weeks and 6 months: weight, BMI, BMI percentile, triceps skin-fold, physical activity (accelerometer) and programme use (weekly log-on rate) Adiposity measures: weight, BMI, BMI percentiles, triceps skin-fold	Technology: Internet (not stand alone) Duration: 9 weeks 20-min weekly skill building activities at troop meetings, drills booklet and Internet-based role modelling, goal setting, review and problem-solving promoting Physical activity twice a week Incentive: badge awarded to participants earning 70% of available points based on attendance, goal setting and achievements	Overall increase in BMI (0.4 kg m ⁻² increase after 9 months) and BMI percentile levels 12 min increase in light intensity physical activity and a trend towards a 12 min decrease in sedentary behaviour in spring participants only No significant change among fall intervention participants or on moderate to vigorous physical activity Programme use: at least 1 log-on per week for 75% and 78% of treatment and control participants respectively
Marks <i>et al.</i> (23)	RCT Students randomized to web (<i>n</i> = 181) or print (<i>n</i> = 178) group Home-based North Carolina, USA	<i>n</i> = 359; 6th–8th graders from four schools; mean age = 12.2; 100% females; 51% African-American Final analysis: <i>n</i> = 319 Attrition: 11%	Print intervention: print workbook containing identical content and graphics to the website	Minimal (information letter received)	Baseline and 2 weeks: physical activity self-efficacy, physical activity intentions and self-reported physical activity Adiposity measures (at baseline only): self-reported weight, BMI, BMI-for-age percentiles	Technology: Internet (stand alone) Duration: 2 weeks Participants encouraged to consult materials at least four times in 2 weeks Web intervention: password protected access to an adapted, interactive <i>LifeBytes</i> website Incentive: \$US10 gift certificate	Both intervention groups significantly increased physical activity self-efficacy and intentions The print group demonstrated significantly greater increases in physical activity intentions compared with the web group Self-reported physical activity increased significantly in the print group only Programme use: N/A
Fienn <i>et al.</i> (16)	Quasi-experimental non-RCT Students assigned to treatment or control based on classroom assignment School-based Wisconsin, USA	<i>n</i> = 132; 7th graders from six classes; ages 12–14; 64% females; ethnically diverse population; predominantly Hispanic Final analysis: <i>n</i> = 103 Attrition: 12%	Three classes completing usual assignments	None	Baseline and 1 month: self-reported physical activity, percentage dietary fat and programme participation level (completion of programme modules) Adiposity measures: none	Technology: Internet (not stand alone) Duration: 1 month Eight Internet sessions (40 min per session) with four 2- to 3-min videos along with computer-generated feedback and tailored individual feedback via emails Incentive: \$US1 school bookstore coupon for returned consent form and \$US2 for completion of assessments	Intervention participants who completed more than half the sessions increased moderate/vigorous physical activity by 22 min (compared with a 46 min decrease in the control group) and decreased dietary fat by 0.8% Programme use: not detailed
Luce <i>et al.</i> (22)	Feasibility study Students assigned to one of four groups based on an online algorithm: no risk (<i>n</i> = 11), eating disorder risk (<i>n</i> = 36), overweight risk (<i>n</i> = 16) and both risks (<i>n</i> = 5) School- and home-based California, USA	<i>n</i> = 176; 10th graders from a private school; 100% females; 57% Caucasian; mean BMI = 22.6 kg m ⁻² Final analysis: <i>n</i> = 174 Attrition: 1%	Participants not at risk of an eating disorder or being overweight completed the core health curriculum only	None	Pre-post outcomes: weight and shape concerns Adiposity measures (at baseline only): self-reported weight, BMI	Technology: Internet (not stand alone) Duration: not detailed Students' level of risk for developing an eating disorder or becoming obese was assessed online and students were invited to participate in one of four interventions appropriate to their risk: universal core health curriculum, targeted body image (BI) enhancement curriculum, targeted weight management (WM) curriculum or combined BI and WM curriculum. All interventions incorporated online components. Only the core and BI interventions were delivered Incentive: N/A	Over half of participants identified as being at risk of overweight or developing an eating disorder chose to receive the recommended targeted curricula All groups showed significant improvements in weight and shape concerns Programme use: N/A

Table 3 Continued

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Long <i>et al.</i> (21)	Quasi-experimental, pre-post study Students assigned to intervention (<i>n</i> = 63) or comparison (<i>n</i> = 58) group based on feasibility study School-based Texas, USA	<i>n</i> = 121; 7th–9th graders from two schools; ages 12–16; median age = 13; 52% females; 47% Caucasian Final analysis: <i>n</i> = 121 Attrition: not mentioned	Control group received nutrition education from the standard school curriculum	None	Baseline and 1 month: self-efficacy for healthy eating, dietary knowledge, food choices, self-reported food intake (fruit, vegetable, fat) Adiposity measures: none	Technology: Internet (not stand alone) Duration: 1 month Five hours of Web-based interactive nutrition education with a gaming approach and 10 h of behaviourally-based, activity oriented classroom curriculum Incentive: N/A	Higher self-efficacy for healthy eating, greater dietary knowledge, and healthier usual food choices in the intervention group No difference between groups in food consumption Programme use: N/A
Fienn <i>et al.</i> (14)	Quasi-experimental non-RCT Students assigned to treatment (<i>n</i> = 67) or control (<i>n</i> = 63) based on classroom assignment School-based African-American Wisconsin, USA	<i>n</i> = 341; 7th–8th graders from two low-middle income schools; ages 12–15; 55% females; control (<i>n</i> = 63) based on ethnically diverse population; predominantly African-American Final analysis: <i>n</i> = 130 Attrition: 62%	Students received the usual curriculum	None	Pre-post outcomes: self-reported moderate and vigorous physical activity and dietary fat intake, and programme participation level (completion of intervention modules) Adiposity measures: none	Technology: Internet (not stand alone) Duration: 1 academic year Six sessions (50 min per session): four Internet/video sessions with online feedback, one healthy snack session and one gym class (one school only) Incentive: N/A	No significant differences between treatment and control groups in dietary fat intake Compared to girls in the control group, dietary fat intake was significantly reduced among African-American, Caucasian and African-American/native girls in the intervention group Dietary fat decreased with each Internet session in which students participated Moderate to vigorous physical activity duration decreased in both control and treatment groups but less in the treatment group; participants receiving the gym lab increased their moderate and vigorous physical activity Programme use: not detailed
Winett <i>et al.</i> (25)	Non-RCT Health education classes assigned to the treatment (four classes; <i>n</i> = 103) or comparison (four classes; <i>n</i> = 180) condition based on computer lab availability School-based (rural) Virginia, USA	<i>n</i> = 180; 9th–10th graders; mean age = 15.4; 100% females; ethnicity not detailed Final analysis: <i>n</i> = 180 Attrition: not mentioned	Comparison group received the basic health curriculum	None	Pre-post outcomes: self-reported intake of regular meals, fruit and vegetables, breads and cereals, high fat snacks, high fat dairy, soda drinks, fast food (for a sub-sample of 39 students) and aerobic activity Adiposity measures: none	Technology: Internet (not stand alone) Duration: programme run each semester during one academic year Once a week for 5 weeks: 15–20 min interactive modules targeting healthy eating; <i>Eat4Life</i> programme used as an adjunct to a health education class and designed as a teen online magazine; both graphic and personalized online feedback provided Incentive: N/A	Significant positive changes in several target nutrition areas (regular meals, fruit and vegetables, breads and cereals, fibre, soda drinks, fast food) and self-reported aerobic activity in the treatment group Programme use: N/A
Russ <i>et al.</i> (24)	Non-RCT, preliminary study Two classes assigned to the treatment (<i>n</i> = 18) or comparison (<i>n</i> = 23) condition based on computer lab availability School-based (rural) Virginia, USA	<i>n</i> = 41; 10th graders from two classes; 100% females; ethnicity not detailed Final analysis: <i>n</i> = 41 Attrition: not mentioned	Comparison class received the basic health curriculum	None	Pre-post outcomes: self-reported intake of regular meals, fruit and vegetables, breads and cereals, high fat snacks, high fat dairy, and soda drinks Adiposity measures: none	Intervention: Internet (not stand alone) Duration: not detailed, assuming 6 weeks Once a week for 6 weeks: 15–20 min interactive modules targeting healthy eating and physical activity; <i>Eat4Life</i> programme used as an adjunct to a health education class and designed as a teen online magazine; both graphic and personalized online feedback provided Incentive: N/A	Significant positive changes in target foods except for intake of soda drinks in the treatment group Programme use: N/A

Attrition includes postenrolment or postrandomization dropouts and participants with missing data at postassessment. BMI, body mass index; CD-ROM, compact disc read-only memory; N/A, not applicable; RCT, randomized controlled trial.

Table 4 Summary of child and adolescent obesity treatment interactive electronic interventions

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Child overweight and obesity treatment interventions							
Moore (26)	Feasibility RCT Eligible families randomly assigned to treatment or control	<i>n</i> = 65; children and their primary care givers; ages 6–12; 70% females; 43% Caucasian; BMI \geq 75th percentile for age and sex; mean BMI = 28.1 kg m ⁻² Final analysis: <i>n</i> = 30 Attrition: 58%	Control group received education from the American Academy of Pediatrics website	Family-based intervention involving primary care givers	Baseline and 6 weeks (based on parental reports): BMI (based on parent-reported child weight), BMI z-score, child health status, health promotion behaviour (diet and physical activity), and weight control skills inventory Adiposity measures: BMI (based on parent-reported child weight), BMI z-score	Technology: Internet (stand alone) Duration: 6 weeks Families in both groups instructed to review programme materials both independently and with their children for 1.5 h per week Families received four individually-tailored, family-based, behavioural weight control skills modules Incentives: N/A	Child health status maintenance and modest improvements in child health promotion behaviour and parental weight management knowledge in the intervention group Stability of BMI and BMI z-scores from baseline to post-intervention for children in both groups, with no clear treatment effects Programme user: N/A
Adolescent overweight and obesity treatment interventions							
Doyle et al. (29)	RCT Participants randomly assigned to treatment or control	<i>n</i> = 83; ages 12–18; mean age = 14.5; 62.5% females; 50% Caucasian; BMI \geq 85th percentile Final analysis: <i>n</i> = 80 (intention-to-treat approach) Attrition: 4%	Control group received educational handouts on nutrition and physical activity	Monthly newsletters mailed to parents and telephone support available to parents	Baseline, post-intervention and 4 months: weight, BMI, BMI z-score, self-reported eating attitudes and behaviours (weight, shape, eating concerns and dietary restraint) and programme use (percentage of screens accessed online and use of journals) Adiposity measures: weight, BMI, BMI z-score	Technology: Internet (stand alone) Duration: 16 weeks Cognitive-behavioural weekly programme (<i>Student Bodies 2</i>) targeting behavioural weight loss and body image improvement, weekly newsletter with personalized feedback and asynchronous discussion group Incentive: \$US20 gift card lottery based on task completion	Significant reduction in BMI z-score (0.08 kg m ⁻²) at 16 weeks in the intervention group Although the intervention group maintained this BMI reduction at 4 months, it was not significantly different from the control group who also improved their BMI No significant effects on eating disorder risk factors Programme use: 30% of treatment participants accessing <10% of programme
Hung et al. (30)	Quasi-experimental, pre-post study	<i>n</i> = 38; adolescents from two schools; ages 12–14; Mean age = 12.62; 68% males; 100% Asian; BMI > 25 kg m ⁻² Final analysis: <i>n</i> = 37 Attrition: 3%	None	None	Baseline and 14 weeks: obesity indices (BMI, waist circumference, hip circumference, waist to hip ratio, mid-arm circumference, triceps), blood pressure, physical fitness and psychosocial variables (weight loss knowledge, body image, self esteem and weight loss self-efficacy) Adiposity measures: BMI, waist circumference, hip circumference, waist to hip ratio, mid-arm circumference, triceps	Technology: Internet (not stand alone) Duration: 14 weeks Weight loss e-learning programme providing weight control information and motivation through games integrated with a student weight loss group consisting of weekly regular classes (45 min each), an exercise and activity course (40 min per session) twice a week, and individual counselling sessions 2–3 times per semester with the author or one of two school teachers (20–30 min per session) Incentive: rewards for biggest BMI reduction, fitness improvement, knowledge increase and best attendance	Significant decreases in BMI (0.43 kg m ⁻²), waist circumference and triceps skin-fold improvements in physical fitness and all psychosocial variables Programme user: N/A

Table 4 Continued

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Schiel <i>et al.</i> (31)	Longitudinal study Hospital- and home-based Germany	n = 140; obese children and adolescents hospitalized for weight reduction; 78% females; mean age = 13.7; ethnicity not detailed; mean BMI = 30.5 kg m ⁻² Final analysis: n = 140 Attrition: unclear	None	None	Baseline, 3 months, 6 months, 9 months and 12 months after hospital discharge: weight, BMI, BMI z-score and psychological assessment (wellbeing, treatment satisfaction, depression and motivation) Adiposity measures: weight, BMI, BMI z-score	Intervention: telemedicine (not stand alone) Duration: variable hospital admission lengths (mean length = 35 days), 12 month telemedicine support programme Two study phases: Phase 1: structured treatment and teaching programme in hospital with the aim of weight reduction; Phase 2: follow-up with the <i>TeleObé</i> telemedicine support programme using Internet and/or a mobile phone; email and/or mobile phone reminders <i>TeleObé</i> integrated data assessment, data collection, visualization and recommendations for further treatment by using Internet services and/or a mobile phone. If required, further treatment involved Internet and/or telephone counselling by a physician, psychologist or a nutrition or exercise educator Incentives: N/A	In patients participating in the telemedicine support programme, there was a stabilization of both BMI and BMI z-score from hospital discharge to 12 months Wellbeing and treatment satisfaction increased between onset of the telemedicine support programme and 6 months follow-up Depression scores decreased significantly and remained stable up to 9 months follow-up Motivation decreased despite a positive increase in eating and exercise behaviour scores Further treatment was needed in 64% of patients during the follow-up period Programme use: N/A
Williamson <i>et al.</i> (27,34)	RCT Stratified by BMI percentile and age; family pairs randomly assigned to treatment (n = 28) or control (n = 29) Home-based Louisiana, USA	n = 57; overweight girls and their overweight parents; ages 11–15; mean age = 13.2; 100% females; 100% African-Americans; BMI > 85th percentile for sex and age range; mean BMI percentile = 96.3 Final analysis: n = 57 (intention-to-treat approach) Attrition: 30%	Parents and adolescents in the control group received a non-interactive Internet health programme without any prescribed behavioural changes or Internet counselling, and four face-to-face nutrition education sessions with a dietitian	Parents in the treatment group received the Internet lifestyle behaviour modification programme	Baseline, 6 months, 12 months, 18 months and 24 months: weight, BMI, BMI percentiles (for girls only), percentage of body fat (DEXA), weight loss behaviours and programme use (number of website hits) Adiposity measures: weight, BMI, BMI percentiles (for girls only), percentage of body fat (DEXA)	Intervention: Internet (not stand alone) Duration: 2 years Over 6 months: weekly nutrition education, interactive activities and Internet counselling behaviour modification using a family-orientated approach targeting lifestyle, eating and physical activity habits; four face-to-face counselling sessions during the first 12 weeks of the programme and asynchronous email communications with a counselor Access to the programme was available for 2 years Incentives: \$US700 voucher to purchase a computer worth ~\$US1000; small gifts for attending face-to-face sessions, \$US30 and \$US10 gift given respectively to parents and girls for completing each assessment; free Internet access	Compared with control participants, adolescents lost more mean body fat (group difference: 1.6%) and parents lost significantly more mean body weight (group difference: 2.1 kg) after 6 months of treatment This weight loss was regained over the next 18 months and after 2 years differences in fat for adolescents and weight for parents did not differ between the intervention and control groups Adolescents and parents in both groups improved weight loss behaviours Programme use: more website hits over 6 months in treatment girls (625) and parents (557) compared to control girls (187) and parents (227)

Table 4 Continued

Study	Design	Participants	Control condition	Parental involvement	Measures	Intervention description	Key findings
Celio (28)	RCT Students randomly assigned to treatment (n = 32) or control (n = 29) Community-based California and Missouri, USA	n = 63; ages 12–18; mean age = 14; 62% females; 47.5% Caucasian; BMI > 85th percentile; mean BMI percentile = 97.7 Final analysis: n = 61 (intention-to-treat approach) Attrition: 8%	Control group received educational handouts on nutrition and physical activity	Monthly newsletters mailed to parents and telephone support available to parents	Baseline and 16 weeks: weight, BMI, BMI z-score, eating disorder attitudes and behaviours, body satisfaction, self-reported physical and sedentary activity, intake of fruit, vegetables, high fat foods and programme use (percentage of screens accessed online and use of journals) Adiposity measures: weight, BMI, BMI z-score	Technology: Internet (stand alone) Duration: 16 weeks Cognitive-behavioural weekly programme (<i>Student Bodies 2</i>) targeting behavioural weight loss and body image improvement, weekly newsletter with personalized feedback and asynchronous discussion group Incentive: pedometer; lottery system based on task completion; control group offered the Internet programme at the end of the study	Significant reduction in BMI z-score (0.09 kg m ⁻²), dietary restraint (however, this was not clinically significant) and high fat food consumption in the intervention group compared with the control group No significant differences in physical or sedentary activity between groups Programme use: 33% of the 353 screens were accessed over 16 weeks; completion of 26%–34% of journals
White et al. (32,33)	RCT Family pairs randomly assigned to treatment (n = 28) or control (n = 29) Home-based Louisiana, USA	n = 57; overweight girls and their obese parents; age: 11–15 years; mean age = 13.2; 100% females; 100% African-Americans; BMI > 85th percentile for sex and age range Final sample: n = 57 (intention-to-treat approach) Attrition: 12%	The control Internet programme provided basic nutrition and physical activity education	Parents in the treatment group received the Internet lifestyle behaviour modification programme	Baseline and 6 months: weight, BMI percentage of body fat (DEXA), dietary self-efficacy, weight loss behaviours, usual eating patterns, psychological measures and programme use (number of website hits) Adiposity measures: weight, BMI percentage body fat (DEXA)	Technology: Internet (not stand alone) Duration: 6 months Health Improvement Program for Teens (<i>HIP-Teens</i>): weekly nutrition education and Internet behaviour modification counselling (via emails with a case manager and automated feedback) using a family-orientated approach targeting healthy eating and physical activity habits Incentives: free computer and Internet access	Compared with control participants, adolescents receiving the intervention lost more mean body fat (group difference: 1.4%) while parents receiving the intervention had a lower BMI (group difference: 0.8 kg m ⁻²) at 6 months Parent variables relating to family and life satisfaction were the strongest mediators of adolescent weight loss while changes in dietary practices were the strongest mediators for parental weight loss Programme use: more website hits over 6 months in treatment girls (625) and parents (557) compared to control girls (187) and parents (227)

Attrition includes postenrolment or postrandomization dropouts and participants with missing data at postassessment. BMI, body mass index; DEXA, dual energy X-ray absorptiometry; RCT, randomized controlled trial.

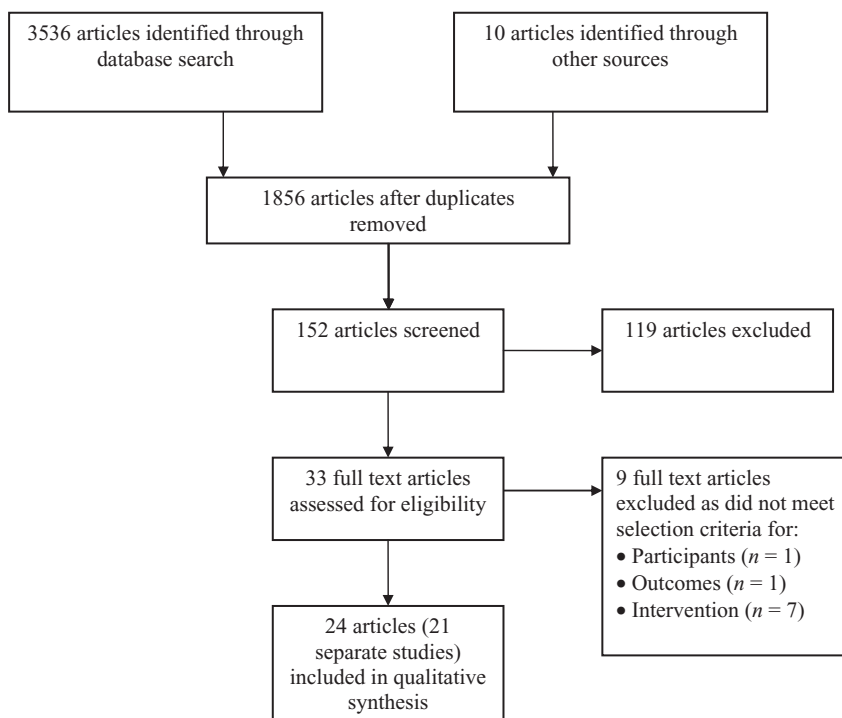


Figure 1 Identifying studies for inclusion in systematic review.

featured CD-ROM (15,17,18), Internet (14,16,19–22,24,25) and video (14,16) components and were mostly delivered in schools (14–18,21,22,24,25). Only one intervention included a parental component (17,18) and two interventions assessed programme use (19,20). Overall, significant positive outcomes were reported in relation to BMI and/or BMI z-score (15,18,20), dietary behaviours (14–17,20,21,24,25), physical activity behaviours (14–17,19,25), improved knowledge (15,21) and attitudes (15,20,21,23).

One CD-ROM-based study was a stand alone non-RCT intervention (15). At 16 weeks, the computer intervention group decreased their BMI by 0.2 kg m⁻² and improved a greater number of obesity-related behaviours than the traditional education or control groups. The other two CD-ROM based studies examined different aspects of the only adolescent prevention intervention in this review that includes a parental component (17,18). This Belgian cluster RCT was delivered as an adjunct to health promotion activities in schools. Compared to either the intervention alone or control groups, the intervention with parental support was effective in reducing BMI z-score (0.07 and 0.17, respectively, at 1 and 2 years) 3 in girls only (18). Improvements in physical activity in both genders and dietary fat intake in girls at 1 year were sustained at 2 years in both intervention groups (i.e. with or without parental involvement) (17).

One out of the nine Internet-based studies was a stand alone programme (20). This 16-week high quality US RCT

was associated with significant reductions in BMI z-score (0.18) and eating disorder behaviours at 9 months, despite modest programme use. Two of the remaining Internet-based studies were short-term RCTs showing improvements in BMI and light physical activity in Boy Scouts (19) and increases in physical activity self-efficacy and intentions in African–American girls (23). The remaining studies featured poor quality (with a score <25%) interventions other than RCTs and did not examine adiposity outcomes (14,16,21,22,24,25).

Treatment

Eight studies focused on obesity treatment interventions in adolescents with six based in the USA (27–29,32–34), one in Taiwan (30) and one in Germany (31) (Table 4). Interventions varied between 12 weeks and 2 years and involved 37 to 140 participants from various ethnic backgrounds between the ages of 11 to 18 years. Seven out of the eight studies included 62–100% female participants (27–29,31–34).

All electronic interventions were delivered via the Internet (27–34) and one involved a telemedicine support programme (31). Except for one school intervention (30), Internet programmes were predominantly home-based. Six out of the eight studies included parental involvement either via printed newsletters and telephone support (28,29), an Internet behavioural programme alone (32,33) or supplemented with face-to-face counselling (27,34). Six studies measured programme use (27–29,32–34). Overall,

significant positive outcomes were reported in relation to BMI and/or BMI z-score (28–30), body fat (27,32–34), psychosocial variables (30,31), dietary and physical activity behaviours (31).

Two high quality US RCTs assessed the impact of a stand alone cognitive-behavioural programme on weight loss and body image improvement in 12 to 18 year olds (28,29). Following 16 weeks of intervention, both studies reported BMI z-score reductions (0.08–0.09 kg m⁻²) which were not maintained at 4 months (29). There were no significant effects on physical activity or sedentary activity (28).

The remaining six studies incorporated interactive electronic interventions as adjunct programmes. Four of these studies were RCTs involving a 6-month Internet behavioural programme targeting African-American girls and their parents (27,32–34). Compared to controls, adolescents receiving the intervention lost more mean body fat while their parents decreased their BMI (group difference: 0.8 kg m⁻²). Variables relating to parental satisfaction with family or life were the strongest mediators of adolescent weight loss (32,33). However, these group differences in adiposity subsided after 2 years (27,34). The two remaining studies observed a significant BMI reduction among Taiwanese students following an Internet-based weight loss programme (30) or stabilization of BMI z-score among obese youth receiving a telemedicine support programme (31).

Discussion

This systematic review provides a qualitative evaluation of 24 studies (4 based in children, 18 in adolescents) incorporating interactive electronic media interventions for the prevention or treatment of obesity and/or obesity-related behaviours in children and adolescents. The majority of studies were published in the last decade, highlighting this relatively novel research area and the growing interest in the potential application of interactive electronic media in youth obesity management or prevention interventions. Most studies featured interactive Internet sites or CD-ROM-based components as adjunct or stand alone programmes. Overall, 17 out of 20 studies that included a comparison group demonstrated positive obesity and/or obesity-related outcomes in favour of the intervention group. However, most studies did not separate the effects of interactive electronic media from other components in the intervention and showed poor overall study design quality. Despite being limited, the available evidence from this systematic review provides some insight in identifying current research gaps and informing future directions for designing youth obesity management or prevention programmes featuring interactive electronic media.

Quality of included studies

The evidence from this systematic review should be viewed with caution because of the heterogeneity of studies and overall poor study design quality. Of the identified studies, less than half were RCTs and only two were deemed to be high quality (with a score >80%) (20,28). Most RCTs and non-RCTs failed to describe randomization, allocation and blinding procedures and half failed to conduct or report intention-to-treat analyses.

Among the few prevention interventions in children, two studies reported positive outcomes in predominantly minority populations (12,13); one of these two studies lacked a control group (12) and the effects of the electronic intervention were not separated from other intervention components in the other study (13). The only treatment trial identified in children did not provide convincing evidence and had study limitations which included a small sample size, a high attrition rate, short intervention duration and poor reporting of methods (26).

The vast majority of adolescent obesity prevention and treatment studies were conducted in the USA, largely in ethnically diverse populations. Only two of these interventions from the same group of researchers and involving a 16-week cognitive-behavioural Internet intervention, achieved relatively high study quality scores (20,28). Overall, the direct transferability of these heterogeneous interventions and subsequent findings to other settings is unclear.

In view of these quality issues, we recommend that future studies rigorously report on methodology and have better design (e.g. inclusion of a control group, isolation of interactive electronic intervention effects, assessment of common core outcome measures, evaluation of programme adherence and possible association with improved outcomes).

Changes in adiposity outcomes

While most studies reporting adiposity outcomes seem to favour independent or adjunct interventions incorporating interactive electronic media, only one-third of studies assessed age and sex-specific BMI z-scores. Half of these studies, including two high quality prevention (20) and treatment (28) Internet stand alone programmes for adolescents, were RCTs showing significant BMI z-score reduction (ranging from 0.07 kg m⁻² at 8 weeks to 0.18 kg m⁻² at 9 months) in the intervention group (13,20,28,29). These findings are comparable in magnitude to those reported in a recent Cochrane review of lifestyle RCTs for the treatment of obesity in young people (pooled effect size: -0.06 in children; -0.14 in adolescents) (4).

The remaining studies in this review also demonstrated positive outcomes with a less significant increase in BMI

z-score following a CD-ROM-based RCT (17,18) or maintenance of BMI z-score after a short-term Internet intervention (26) or long-term adjunct telemedicine programme (31).

Changes in obesity-related behaviours

Most studies suggest that interactive electronic interventions, used as adjunct or stand alone programmes, positively influence obesity-related outcomes including dietary behaviours (e.g. decreased dietary fat intake), reported and measured physical activity and psychosocial variables (e.g. self-efficacy). Several studies report mixed findings or no clear impact of interactive electronic interventions on obesity-related outcomes (11,13,14,17–21,24), and one reported better outcomes in the comparison group (23).

Parental involvement

Research indicates that paediatric weight management programmes involving parents have better outcomes than programmes that do not (37). However, less than half of the studies included in this review targeted both young people and their parents (11,13,17,18,26–29,32–34). In comparing these studies, the impact of parental involvement on children's obesity and/or obesity-related outcomes remains unclear because of different types of parental components involved, most studies not assessing the level of parental involvement and lacking a comparison group. In four RCTs with a comparison group and in which parents received a separate 6-month Internet behavioural programme (27,32–34), parent variables relating to family and life satisfaction were the strongest mediators of adolescent weight loss (32,33). However, positive adiposity outcomes were lost at 2 years (27,34). Further research is needed in investigating the implications of varying modes of parental involvement in youth interactive electronic interventions for the prevention or treatment of obesity.

Impact of interactive electronic interventions

Overall, many interventions incorporated multiple components and, while most showed positive results, 87% failed to separate the effects of the electronic intervention from other intervention components including school-based or community-based education, physical activity sessions and individual counselling. The individual effects of different electronic components (e.g. educational tasks, individualized emails, computer-tailored feedback, online discussion groups) within electronic interventions were also not evaluated. Only six out of 24 studies (two conducted in children, four in adolescents) featured stand alone electronic interventions (12,20,23,26,28,29). These Internet-based interventions demonstrated significant obesity

reduction (20,28,29) despite indeterminate effects on obesity-related outcomes. Importantly, most interventions did not assess programme use and its impact on intervention effectiveness.

Strengths and limitations

Two recent systematic reviews highlight the potential for electronic interventions in improving weight-related behavioural change in children and adolescents but recommend that further research is conducted (5,6). Compared with the existing reviews, the current review includes a much broader range of study designs, settings and types of interactive electronic interventions. In this review, study quality was evaluated using established standards and studies were described on multiple dimensions in a systematic and detailed approach. The heterogeneity in study designs, settings, sample characteristics, intervention components and outcomes, precluded a quantitative analysis of the impact of interactive electronic interventions on prevention or treatment of obesity and/or obesity-related outcomes. The review was also limited by the small number of quality interventions and the lack of isolation of the effects of interactive electronic components.

Conclusions

Research gaps in the existing evidence base include high-quality well-designed long-term trials, particularly those relating to the prevention of obesity; studies incorporating innovative electronic media such as social networking media (e.g. Facebook) and e-whiteboards; studies that can be generalized to other populations; studies targeted towards both young people and their parents; studies that isolate the effects of interactive electronic media interventions; and studies that examine programme user engagement, adherence and the relationship between intervention dose and outcomes. While electronic interventions appear a promising approach for the prevention and treatment of obesity in children and adolescents, based on the available evidence it is clear that further high quality research is required to accurately inform the evidence base.

Conflict of Interest Statement

No conflicts of interest exist.

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References

1. Wang YL, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; **1**: 11–25.
2. Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. Report of the International Obesity Taskforce Childhood Obesity Working Group. *Obes Rev* 2004; **5**: 4–104.
3. Summerbell CD, Waters E, Edmunds LD, Kelly S, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2005; **3**: CD001871.
4. Oude LH, Baur L, Jansen H, Shrewsbury VA, O'Malley C, Stolk RP, Summerbell CD. *Cochrane Database Syst Rev* 2009; **1**: CD001872.
5. Tate DF. Application of innovative technologies in the prevention and treatment of overweight in children and adolescents. In: Jelalian E, Steele RG (eds). *Handbook of Childhood and Adolescent Obesity*. Springer Science + Business Media: New York, 2008, pp. 378–404.
6. An JY, Hayman LL, Park YS, Dusaj TK, Ayres CG. Web-based weight management programs for children and adolescents: a systematic review of randomized controlled trial studies. *Adv Nurs Sci* 2009; **32**: 222–240.
7. Neve M, Morgan PJ, Jones PR, Collins CE. Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. *Obes Rev* 2010; **11**: 306–321.
8. Cochrane Consumers and Communication Review Group. Data extraction template for cochrane reviews. [WWW document]. URL http://www.latrobe.edu.au/chcp/assets/downloads/DET_2009update.doc (accessed November 8 2010).
9. Ryan R, Hill S, Broclain D, Horey D, Oliver S, Prictor M, Cochrane Consumers and Communications Review Group. Study quality guide. [WWW document]. URL <http://www.latrobe.edu.au/chcp/assets/downloads/StudyQualityGuide050307.pdf> (accessed November 8 2010).
10. Department of Information Services, University of Wales College of Medicine. Appraisal checklists. [WWW document]. URL <http://hebw.cf.ac.uk/methodology/appendix7.htm> (accessed November 8 2010).
11. Baranowski T, Baranowski JC, Cullen KW, Thompson DI, Nicklas T, Zakeri IE, Rochon J. The fun, food, and fitness project (FFFP): the baylor GEMS pilot study. *Ethn Dis* 2003; **13** (Suppl. 1): S30–S39.
12. Thompson D, Baranowski T, Cullen K, Watson K, Liu Y, Canada A, Bhatt R, Zakeri I. Food, fun, and fitness internet program for girls: pilot evaluation of an e-health youth obesity prevention program examining predictors of obesity. *Prev Med* 2008; **47**: 494–497.
13. Goran MI, Reynolds K. Interactive multimedia for promoting physical activity (IMPACT) in children. *Obes Res* 2005; **13**: 762–771.
14. Frenn M, Malin S, Bansal N, Delgado M, Greer Y, Havice M, Ho M, Schweizer H. Addressing health disparities in middle school students' nutrition and exercise. *J Community Health Nurs* 2003; **20**: 1–14.
15. Casazza K, Ciccazzo M. The method of delivery of nutrition and physical activity information may play a role in eliciting behavior changes in adolescents. *Eat Behav* 2007; **8**: 73–82.
16. Frenn M, Malin S, Brown RL, Greer Y, Fox J, Greer J, Smyczek S. Changing the tide: an Internet/video exercise and low-fat diet intervention with middle-school students. *Appl Nurs Res* 2005; **18**: 13–21.
17. Haerens L, Deforche B, Maes L, Cardon G, Stevens D, De Bourdeaudhuij I. Evaluation of a 2-year physical activity and healthy eating intervention in middle school children. *Health Educ Res* 2006; **21**: 911–921.
18. Haerens L, Deforche B, Maes L, Stevens V, Cardon G, De Bourdeaudhuij I. Body mass effects of a physical activity and healthy food intervention in middle schools. *Obesity* 2006; **14**: 847–854.
19. Jago R, Baranowski T, Baranowski JC, Thompson D, Cullen KW, Watson K, Liu Y. Fit for Life Boy Scout badge: outcome evaluation of a troop and Internet intervention. *Prev Med* 2006; **42**: 181–187.
20. Jones M, Luce KH, Osborne MI, Taylor K, Cuning D, Doyle AC, Wilfley DE, Taylor CB. Randomized, controlled trial of an internet-facilitated intervention for reducing binge eating and overweight in adolescents. *Pediatrics* 2008; **121**: 453–462.
21. Long JD, Stevens KR. Using technology to promote self-efficacy for healthy eating in adolescents. *J Nurs Scholarsh* 2004; **36**: 134–139.
22. Luce KH, Osborne MI, Winzelberg AJ, Das S, Abascal LB, Celio AA, Wilfley DE, Stevenson D, Dev P, Taylor CB. Application of an algorithm-driven protocol to simultaneously provide universal and targeted prevention programs. *Int J Eat Disord* 2005; **37**: 220–226.
23. Marks JT, Campbell MK, Ward DS, Ribisl KM, Wildemuth BM, Symons MJ. A comparison of web and print media for physical activity promotion among adolescent girls. *J Adolesc Health* 2006; **39**: 96–104.
24. Russ CR, Tate DF, Whiteley JA, Winett RA, Winett SG, Pflieger J. The effects of an innovative WWW-based health behavior program on the nutritional practices of tenth grade girls: preliminary report on the Eat4Life program. *J Gen Educ Health* 1998; **3**: 121–128.
25. Winett RA, Roodman AA, Winett SG, Bajzek W, Rovniak LS, Whiteley JA. The effects of the Eat4Life Internet-based health behavior program on the nutrition and activity practices of high school girls. *J Gen Educ Health* 1999; **4**: 239–254.
26. Moore BA. *Examining Fit Web: A New Approach to the Conceptualization and Treatment of Pediatric Obesity*. U Navada: Reno, NV, 2007.
27. Williamson DA, Walden HM, White MA, York-Crowe E, Newton RL Jr, Alfonso A, Gordon S, Ryan D. Two-year internet-based randomized controlled trial for weight loss in African-American girls. *Obesity* 2006; **14**: 1231–1243.
28. Celio AA. *Early Intervention of Eating- and Weight-Related Problems Via the Internet in Overweight Adolescents: A Randomized Controlled Trial*. U California, San Diego; San Diego State University: San Diego, CA, 2005.
29. Doyle AC, Goldschmidt A, Huang C, Winzelberg AJ, Taylor CB, Wilfley DE. Reduction of overweight and eating disorder symptoms via the Internet in adolescents: a randomized controlled trial. *J Adolesc Health* 2008; **43**: 172–179.
30. Hung SH, Hwang SL, Su MJ, Lue SH, Hsu CY, Chen HL, Chen HS. An evaluation of a weight-loss program incorporating E-learning for obese junior high school students. *Telemed J E Health* 2008; **14**: 783–792.
31. Schiel R, Beltschikow W, Radon S, Kramer G, Schmiedel R, Berndt RD, Stein G. Long-term treatment of obese children and adolescents using a telemedicine support programme. *J Telemed Telecare* 2008; **14**: 13–16.
32. White MA. Mediators of weight loss in an internet-based intervention for African-American adolescent girls. *Diss Abstr Int: Sect B: Sciences Engineering* 2004; **7**(7-B): 3546.

33. White MA, Martin PD, Newton RL, Walden HM, York-Crowe EE, Gordon ST, Ryan DH, Williamson DA. Mediators of weight loss in a family-based intervention presented over the internet. *Obes Res* 2004; **12**: 1050–1059.
34. Williamson DA, Martin PD, White MA, Newton R, Walden H, York-Crowe E, Alfonso A, Gordon S, Ryan D. Efficacy of an internet-based behavioral weight loss program for overweight adolescent African-American girls. *Eat Weight Disord* 2005; **10**: 193–203.
35. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Prentice-Hall: Englewood Cliffs, NJ, 1986.
36. Prochaska JO, Di Clemente CC, Norcross JC. In search of how people change: applications to addictive behaviors. *Am Psychol* 1992; **47**: 1102–1114.
37. National Health and Medical Research Council of Australia. *Clinical Practice Guidelines for the Management of Overweight and Obesity in Children and Adolescents*. [WWW document]. URL [http://www.health.gov.au/internet/main/publishing.nsf/Content/obesityguidelines-guidelines-children.htm/\\$FILE/children.pdf](http://www.health.gov.au/internet/main/publishing.nsf/Content/obesityguidelines-guidelines-children.htm/$FILE/children.pdf) (accessed November 8 2010).