



Review article

Impact of Computer-Mediated, Obesity-Related Nutrition Education Interventions for Adolescents: A Systematic Review

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Article history: Received September 3, 2013; Accepted December 17, 2013

Keywords: Adolescent; Systematic review; Internet; Computer based; Computer mediated; Intervention studies; Nutrition education; Overweight; Obesity

A B S T R A C T

Purpose: The purpose of this systematic review was to evaluate recent research regarding the use of computer-based nutrition education interventions targeting adolescent overweight and obesity.

Methods: Online databases were systematically searched using key words, and bibliographies of related articles were manually searched. Inclusion/exclusion criteria were applied and included studies evaluated for their ability to achieve their objectives and for quality using the Nutrition Evidence Library appraisal guidelines for research design and implementation.

Results: Of the 15 studies included, 10 were randomized controlled trials. Two studies targeted weight loss, 2 targeted weight maintenance, and 11 targeted dietary improvement with or without physical activity. At least half of in-school (60%) and nonschool interventions (80%) exhibited significantly positive effects on nutrition- or obesity-related variables. Small changes in diet, physical activity, knowledge, and self-efficacy were shown; however, few results were sustained long term.

Conclusions: Recommendations included application of health behavior theory and computer tailoring for feedback messages. Future research should include thorough description of intervention content (messages, theory, multimedia, etc.), application of rigorous methodology, as well as consideration of covariates such as parental involvement and gender. With further research and evidentiary support, this approach to obesity-related nutrition education has the potential to be successful.

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IMPLICATIONS AND CONTRIBUTION

Computer-mediated nutrition education programs for adolescents show small, mainly short-term, changes in obesity outcomes, for example, body mass index (BMI), diet, nutrition knowledge, and physical activity. Future interventions may benefit from health behavior theory and computer-tailored feedback yet should also adhere to rigorous research methodology and consider mediating factors, for example, gender and parental involvement.

The prevalence of overweight in adolescents continues to be a public health concern. The 2009–2010 National Health and Nutrition Examination Survey revealed that 18.4% of adolescents aged 12–19 years were obese [1]. In 2011, the Centers for Disease Control and Prevention estimated that 15% of high-school students were overweight and 13% were obese [2]; furthermore, among certain at-risk ethnic groups, the figures were almost double the national average [3]. The short- and long-term co-morbidities of

adolescent overweight and obesity are numerous: insulin resistance and hyperinsulinemia, type 2 diabetes, hyperlipidemia, lowered high-density lipoprotein cholesterol, hypertension, gallstones, sleep apnea, asthma, depression, and anxiety [4]. In addition, adolescent obesity has been associated with higher school absenteeism [5] and lower quality of life [6]. Improving nutrition and related health behaviors can alleviate some or all these conditions; however, prevention remains a top strategy to combat adolescent overweight and obesity. Global trends are similar to the United States, with child and adolescent overweight increasing especially in urban areas [7]. Therefore, nutrition education focused on obesity prevention in youth is a global public health priority. Because adolescence is marked as a crucial risk period for the

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development of obesity and its related consequences, targeting obesity at the threshold of adulthood is critical [8].

To target nutrition in adolescents, it has been suggested that interventions have a behavioral focus and use innovative multimedia technology tools [9]. With the wide reach of computers and Internet both inside and outside of school and their heavy use among adolescents, it follows that nutrition education would benefit from computer-based delivery. Nearly 90% of adolescents use the Internet, with computer usage and communications tools continuing to increase among youth [10,11]. Computers are available in 97% of U.S. schools, with Internet access available for over 90% of computers in schools [12]. In addition, slightly more than 75% of households had computers in 2011 [13]. Therefore, computers are a resource for learning at home and at school.

Previous computer interventions for adolescent health have targeted smoking cessation, HIV prevention, alcohol abuse, as well as teenage pregnancy prevention [14–19], and this method has grown in popularity within the last 10 years. As the prevalence of overweight and related disease in youth has increased, so has computer-based program development and implementation for nutrition education. Computer interventions have the potential to provide standardized and effective program transmission, as well as the speed of technology. However, research to support the programs' overall impact has yet to catch up.

Therefore, the objective of this systematic review was to evaluate the overall effectiveness of computer-based interventions that provided nutrition education related to adolescent overweight prevention or treatment. To do so, the specific aims were to evaluate the success of each intervention in achieving their objectives, based on their reported statistically significant outcomes ($p < .05$) and if those effects were sustained at follow-up; to identify which intervention characteristics were associated with improvement of nutrition- and/or obesity-related outcomes; and, based on the body of evidence, to ascertain limitations of research and recommendations for research and practice.

Methods

Literature search

A systematic literature search (Figure 1) was conducted via five Internet databases (PubMed, CINAHL, Google Scholar, Proquest, and Scopus). In addition, a manual search of relevant material was conducted to prevent overlooking possible entries. The manual search included articles with related content that were electronically suggested during the online search; bibliographies of accepted articles and related review articles; and online journal archives with content related to health, obesity, nutrition, technology, and communication. The National Library of Medicine's Medical Subject Headings search terms and non-Medical Subject Headings terms were included in a combination of at least one key term from each sublisting: (1) web based, Internet, Internet-based, online, computer, and computer based; (2) adolescent and youth; and (3) diet, nutrition, intervention, nutrition intervention, obesity, obesity prevention, weight loss, weight maintenance, weight management, and health promotion.

To be included, articles must have (1) an adolescent sample population between 7th and 12th grades or 12–18 years of age; (2) implemented an Internet- or computer-based education or behavioral intervention via a stationary or laptop computer; (3) published between January 2002 and August 2013; (4) employed a randomized controlled trial (RCT), quasi-experimental trial, or

intervention with no concurrent control; (5) published in a peer-reviewed journal; and (6) written in English. Both theory-based and nontheoretical interventions were included. Studies must have measured nutrition-related outcomes (e.g., diet composition and nutrition knowledge) and/or obesity-related outcomes (e.g., BMI, BMI z-score, weight, and sedentary behavior). Study designs that included one or more parents were considered only if the primary target of the research was the adolescent. Studies that included noncomputer adjunct components and/or social or environmental changes were considered only if the main method of intervention was the computer-facilitated program. Exclusion criteria included the following: (1) interventions with >50% noncomputer component(s); (2) a study population <7th or >12th grade, or <12 or >18 years of age; (3) a focus on physical activity only; and (4) articles that were not peer reviewed.

Quality ratings

Each article was reviewed separately by the two authors using the U.S. Department of Agriculture (USDA) National Evidence Library's (NEL) appraisal guidelines for research design and implementation [20] and given a quality rating of positive, negative, or neutral. The two reviewers convened to finalize quality ratings and to complete a cross-sectional review of four weighted validity questions to confirm that these were graded consistently and accurately. The authors used the Conclusion Grading Chart developed by the 2010 Dietary Guideline Advisory Committee to determine a grade for the body of evidence [21].

Results

An intermediate review of 33 articles was conducted by each author, and 18 articles were excluded. The remaining 15 articles underwent a full review during which a detailed evidence worksheet was assembled (Table 1) and quality assessed revealing 10 positive ratings, three neutral, and two negative. The body of evidence received a grade of "Limited".

Most studies focused on a 7th to 8th grade population; six included high-school-aged students [22–27]. Half of the interventions targeted adolescent subpopulations including low-income minorities, minority females, overweight/obese adolescents, or overweight/obese minorities [22,23,28–32]. Two interventions targeted disordered eating behaviors, including overeating and binge eating, in addition to instruction on healthy eating and lifestyle behaviors [22,23]. Twelve programs focused on multiple nutrition-related energy balance behaviors, whereas the remaining three focused on either fruit and vegetable (F/V) consumption [32,33] or dietary fat [34]. Eight interventions also added strategies and/or feedback to increase the amount of physical activity [24,26,27,29–31,35,36].

Significant findings ($p < .05$) are reported below. Gender differences and sample sizes for intervention (I) and control (C) groups are given when available. Follow-up times are listed as time since post-treatment assessment.

Impact on nutrition- and obesity-related outcomes

Randomized controlled trials for weight loss ($n = 2$). In an earlier report, Williamson et al. [37] indicated that during the first 6 months, adolescents decreased their percentage body fat (I: -1.12% ; C: $+43\%$). In the 2-year report [28], at 6 and 12 months,

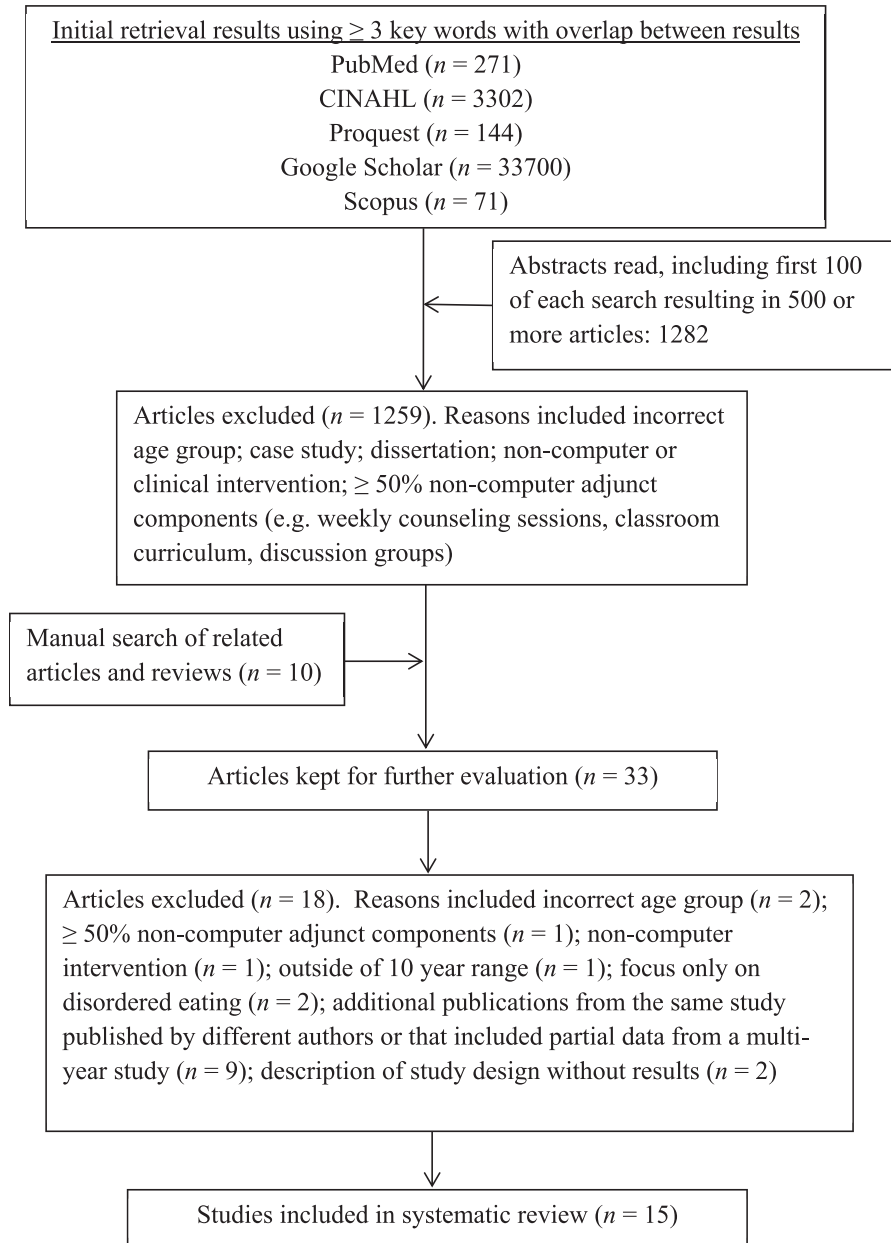


Figure 1. Retrieval and inclusion/exclusion process for articles used in review.

adolescents in the intervention group also showed lower increases in BMI (I: .0 and +.24 kg/m²; C: +.75 and +1.4 kg/m², approximately), yet had regained weight over the second year to be statistically undifferentiated from control. Adolescents reported declines in fatty food consumption at 12 and 18 months; however, after 2 years, consumption mirrored the control group.

Doyle et al. [22] recorded a significant decrease in BMI z-score from baseline to postintervention (I: -.08, n = 33; C: +.01, n = 33). This amounted to a stabilization of weight for the intervention group (I: -.06 kg) compared with weight gain by the control group (C: +2.14 kg). However, during the 4-month follow-up, weight increased in both groups (I: +1.9 kg; C: +1.69 kg) and increases in mean height reduced overweight

status, resulting in an insignificant difference between groups for BMI z-score, BMI, and weight. Dietary restraint scores, related to the control of binge eating, increased in the intervention group (I: +.51; C: -.38).

Randomized controlled trials for weight gain prevention (n = 2). At the 4-month follow-up, Ezendam et al. [35] discovered the intervention group lowered intake of snacks (I: -.6 pieces/day, n = 412; C: +.3 pieces/day, n = 360), increased intake of vegetables (I: +11 g/day, n = 436; C: -7 g/day, n = 377), and had lower odds of drinking >400 ml/day of sugar-sweetened beverages (SSBs), none of which were retained at the 2-year follow-up. Although BMI and waist circumference were not measured at the

Table 1

Evidence table of Internet- and computer-based nutrition education interventions for adolescents (n = 15)

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
Nonschool interventions (n = 5)			
Williamson (2006) [28] Positive	11–15 years Overweight/obese African-American females One obese parent n = 40	<p>HIPTeens</p> <p>Purpose: Weight loss and healthy lifestyle promotion for African-American adolescent females at risk for chronic obesity</p> <p>Intensity: 52 lessons; 1 year</p> <p>Design: RCT; Internet based; interactive behavior theory versus passive health education; 52 weekly lessons for 1 year, had access during year 2; assessments at baseline and every 6 months up to 24 months; four face-to-face counseling sessions for both groups; computers and Internet provided to both groups; culturally relevant; child–parent dyads recruited; parents received same number of lessons; child and parent had separate login information</p> <p>Power analysis: Adequately powered</p> <p>Follow-up^b: 6, 12, 18, and 24 months</p> <p>Intervention: Nutrition education plus an e-mail counseling behavior modification to change eating behavior and physical activity; e-mail correspondence from counselor provided feedback about program components; weight/activity/food graphs to self-monitor; quizzes after each lesson with instant feedback; training in problem solving to overcome barriers</p> <p>Control: Passive health education about nutrition and physical activity without behavior modification nor Internet counseling; no interactive elements other than weight graph and e-mail contact</p> <p>Attrition: 30% by 24 months</p> <p>StudentBodies-2</p> <p>Purpose: Weight loss and improvement of disordered eating behavior in overweight/obese adolescents</p> <p>Intensity: 16 sessions; 16 weeks</p> <p>Design: RCT; Internet-based; two cohorts in two different cities; adolescents received a pedometer; gender-specific interfaces for visual appeal and gender-specific content; logon data and online journal use measured; height and weight collected by trained professional</p> <p>Power analysis: Adequately powered</p> <p>Follow-up: 4 months</p> <p>Intervention: Nutrition education included portion sizes, recommended daily activity, guided behavior modification for weight control, cognitive exercises for body image improvement; first half of program focused on weight loss and second half focused on body image improvement; online journals for tracking food, physical activity, and weight; weekly newsletter e-mailed to intervention participants containing individualized feedback; online body image journal; online asynchronous discussion forum guided by a moderator for social support; parents received monthly newsletters</p> <p>Control: Usual care; received colored handouts with basic information on nutrition and physical activity without behavior modification</p> <p>Attrition: 20.5% by 4-month follow-up</p> <p>Purpose: Promote F/V consumption in economically disadvantaged African-American adolescents</p> <p>Intensity: Four 30-minute sessions; 4 weeks</p> <p>Design: CD-ROM program; quasi-experimental; TTM; 27 youth agencies recruited in three cities</p> <p>Power analysis: None</p> <p>Follow-up: None</p> <p>Intervention: Stage-matched feedback; introductory session served as orientation to program and</p>	<p>6 months:</p> <p>↓ Adolescent percentage body fat; ↓ parent body weight; ↓ parent BMI (all treatment groups)</p> <p>12 months: ↓ BMI for parents in treatment group</p> <p>18 months: Body weight/percentage body fat/BMI NS between groups</p> <p>24 months: Body weight/percentage body fat NS between groups; ↑ adolescent avoidance of fatty foods ($p < .05$); ↑ parent exercise ($p < .05$)</p> <p>Other: Baseline parent body weight covariate for weight change ($p < .0001$); baseline adolescent BMI percentile covariate for changes in BMI ($p < .001$);</p>
Doyle (2008) [22] Positive	12–18 years Overweight and obese Ethnically diverse n = 66	<p>Postintervention: ↓ BMI z-score in the treatment group ($p = .027$); intent-to-treat analysis showed NS results between groups for BMI z-score; ↑ dietary restraint in treatment group ($p = .016$)</p> <p>4 months: BMI z-score, BMI, and weight NS between groups; ↓ shape concern in both groups ($p = .044$)</p> <p>Other: ↑ Use of eating related and physical activity-related skills in treatment group; intervention participants read an average of 30% of intervention material (range 0%–09.7%); 35% of participants viewed <10% of intervention</p>	
Di Noia (2008) [32] Neutral	11–14 years Low income African-American n = 507	<p>Postintervention: ↑ F/V consumption in the treatment group ($p < .001$); ↑ perceived benefits of eating F/V in the treatment group ($p < .025$)</p> <p>Other: Higher proportions of intervention participants moved from earlier to later stages of change; higher proportion of intervention participants stayed in action/maintenance stage ($p < .05$).</p>	

Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
Jones (2008) [23] Positive	9th–12th grade Overweight/obese; Binge-eating n = 87	discussed health benefits of eating ≥ 5 F/V per day; next three sessions determined by stage and contained stage-matched sessions with relevant processes of change Control: Regular programs at youth sites Attrition: 8% due to inconsistent attendance, discontinuation of afterschool program StudentBodies-2-BED Purpose: Weight maintenance and reduction of disordered eating in overweight and obese adolescents Intensity: 16 sessions; 16 weeks Design: RCT; Internet-based; two high schools recruited from two states; height and weight collected by trained research assistants at baseline and follow-up, not postintervention; intention-to- treat and completer analyses Power analysis: Adequately powered Follow-up: 5 months Intervention: Aimed to reduce binge eating, maintain weight, increase healthy eating, increase physical activity, and reduce sedentary activities; content included self-help information for binge eating, the adolescent weight loss intervention Healthy Habits, ^c hunger and satiety awareness skills, ^d food substitution, stimulus control, portion control, coping and self-esteem, and emotion regulation skills; three 24-hour food and physical activity recalls in program; online journals for food, physical activity, weight, goals, and personal thoughts; asynchronous discussion group monitored by moderator; handbook for parents; weekly letters and motivational messages sent to participants to reinforce participation Control: Wait-list Attrition: 17.1%	Post-treatment: \downarrow Objective and subjective binge episodes in the treatment group ($p < .01$) 5 months: \downarrow BMI ($p < .01$) and BMI z-score ($p < .01$) in the treatment group in intention-to-treat and completer analyses; \downarrow objective and subjective binge episodes in the treatment group ($p < .05$); \downarrow weight/shape concerns in the treatment group among completers ($p < .05$), not intention-to-treat Other: NS for dietary fat or sugar intake between groups; 27% of intervention participants completed ≥ 8 weeks of program; 42% completed 1–7 weeks; 31% never logged into program; food journal most commonly used
Chen (2011) [29] Positive	12–15 years Normal weight, overweight, Chinese, and Chinese-American n = 50	Web ABC Study Purpose: Promote healthy diet, physical activity, and healthy weight in Chinese and Chinese-American adolescents Intensity: Eight 15-minute sessions; 8 weeks Design: RCT; Internet-based; TTM and social cognitive theory; child–parent dyad; parents received three 15-minute sessions in 8 weeks; child and parent had separate login information; culturally relevant; each participant received a pedometer and actigraph monitor; data collection by trained professional for pre- and post-test Power analysis: Inadequately powered, needed n = 54 Follow-up: 4 and 6 months Intervention: Stage-matched feedback; nutrition curriculum adapted from the American Dietetic Association's material on (1) the food pyramid; (2) the big three; (3) portion size; and (4) meal planning and from the American Heart Association's material on HeartPower; interactive dietary preparation software "The Wok" developed by Joslin Diabetes Center let participants make a dish and check the nutrition information; online activity diary and F/V diary; graphics, comics, voiceover included in adolescent intervention; parent intervention provided information to increase knowledge and skills regarding healthy food preparation, adolescent eating habits, family activities to encourage healthy eating and physical activity	Results: More adolescents in the intervention group, \downarrow waist-to-hip ratio ($p = .02$), \downarrow diastolic blood pressure ($p = .02$), \uparrow physical activity (actigraph; $p = .01$), \uparrow F/V intake ($p = .001$), \uparrow nutrition knowledge ($p = .001$) and physical activity knowledge ($p = .008$); no change in BMI for either group

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Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
In-school interventions (n = 10) Frenn (2003) [30] Negative	12–15 years 7th–8th grade Urban Low income n = 130	Control: Internet intervention; eight sessions for 8 weeks; Nontailored, general health information about nutrition, dental care, safety, dermatology, risky behavior; graphics, comics, voiceover included Attrition: 20.6% by 6-month follow-up Purpose: Decrease dietary fat and increase moderate-to-vigorous physical activity Intensity: Six 50-minute sessions; 4 weeks Design: Internet-based; quasi-experimental; two middle schools recruited, treatment assigned by classroom; transtheoretical and health promotion models; gym lab only in one school; 1-day food diary completed via Internet program; nursing students to help with “labs” (in-person group sessions); compared gender and ethnicity Power analysis: None Follow-up: None Intervention: Four interactive educational lessons plus four videos (2.5–3 minutes/video) with two peer-led healthy snack and gym labs; nutrition education included fat content in foods, nutrition label reading for fat content, healthy alternatives for foods, calculating calorie balance from physical activity, and preparation of healthy snacks Control: Usual school curriculum Attrition: 62% deleted due to missing data	Postintervention: NS for percentage dietary fat between groups; ↓ moderate-to-vigorous physical activity, less decrease in intervention group; ↑ physical activity for all ethnicities except Native Americans in the treatment group; ↑ physical activity of those with gym lab ($p = .042$) Gender: ↓ Percentage dietary fat for females in the treatment group versus control ($p < .018$); Other: ↑ Access to low-fat foods for White, Hispanic Asian females in the treatment group
Frenn (2005) [31] Positive	7th grade Low income Culturally diverse n = 103	Purpose: Decrease dietary fat and increase moderate/vigorous physical activity in middle-school students Intensity: Eight 40-minute sessions; 4 weeks Design: Quasi-experimental; Internet-based; transtheoretical and health promotion models; conducted during science class; analysis included only students who completed ≥half of the intervention sessions for each section, physical activity, and nutrition Power analysis: None Follow-up: None Intervention: Six interactive educational lessons plus four videos (2.5–3 minutes/video) with two peer-led healthy snack and gym labs; computer-tailored feedback based on stage of change provided for both dietary fat and physical activity; nutrition education included the same content from previous trial (Frenn 2003) plus computerized preparation of healthy snacks, importance of eating breakfast and refraining from night eating, and balancing calories with physical activity; individualized feedback e-mailed to students Control: Usual curriculum Attrition: 23% by postintervention	Postintervention: ↑ Moderate-to-vigorous physical activity in the treatment group for students completing ≥half of the physical activity sessions ($p = .05$); ↓ percentage of dietary fat ($p = .008$) in the treatment group for students completing ≥half of the nutrition sessions Other: ↑ Moderate-to-vigorous physical activity and ↓ dietary fat for all ethnicities who completed ≥half of the sessions for each section
Haerens (2006) [36] Neutral	7th–8th grade 13–14 years Flemish n = 2,287	Purpose: Increase physical activity and healthy eating in middle-school students Intensity: One 50-minute session; once per year for 2 years Design: RCT; CD-ROM program; TTM and theory of planned behavior; 15 schools recruited; two intervention groups (parental involvement vs. no parent) and control; accelerometer subsample of one seventh-grade class from each school (n = 258); “Work group” organized and trained at each intervention school to carry out intervention; compared gender and first year to second year Power analysis: None Follow-up: 12 and 24 months Intervention: Participants received interventions for physical activity and fat intake; computerized questionnaires regarding demographics, physical activity, fat and fruit intake, and psychosocial	12 months: ↑ School-related physical activity and accelerometer results in boys and girls 24 months: Slowed decline in light physical activity in boys ($p < .001$) and girls ($p < .05$) Gender: ↓ Girls' fat intake at 12 and 24 months ($p < .05$); ↓ girls' percentage energy from fat ($p < .001$); ↑ school-related physical activity in boys ($p < .05$) at 24 months; moderate-to-vigorous physical activity stable in boys stable after 24 months versus decrease in control ($p < .05$) Other: NS for parental involvement versus no parent groups for girls' fat intake ($p = .60$); NS for leisure-time physical activity, fruit or SSB intake among all three groups

Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
Haerens (2007) [34] Positive	7th grade 12–13 years Flemish n = 304	<p>determinants of physical activity and fat intake; tailored feedback immediately displayed on screen included normative feedback and feedback on intentions, attitudes, self-efficacy, social support, knowledge, and perceived benefits and barriers; five to six pages of feedback; changes in school environment: schools to create environments conducive to increasing physical activity, fruit, and water intake; parents invited to meeting at school, received information folder and copies of original adult versions of interventions for physical activity and fat intake, and received health information printed in school news materials</p> <p>Control: No intervention</p> <p>Attrition: 23.5% by 24-month follow-up due mainly to absence, leaving school, incorrect questionnaires</p> <p>Purpose: Reduce dietary fat in adolescents</p> <p>Intensity: One 50-minute session</p> <p>Design: RCT; CD-ROM program; TTM, theory of planned behavior, social cognitive theory, and attitude, social influence and self-efficacy model; 10 schools recruited, five general education and five technical-vocational education; two classes of seventh graders randomized from each school into two groups; tailored feedback database of 281 messages; compared general schools to technical-vocational schools and compared gender</p> <p>Power analysis: Adequately powered</p> <p>Follow-up: 3 months</p> <p>Intervention: Three program sections: (1) introduction page to explain diagnostic tool; (2) diagnostic tool that collected demographic information, dietary fat intake, and psychosocial determinants of dietary fat intake (attitude, self-efficacy, social support, perceived benefits, perceived barriers); and (3) five to six pages of tailored intervention messages that included normative feedback about fat intake, lower-fat food alternatives, and tailored feedback about psychosocial determinants</p> <p>Control: No intervention</p> <p>Attrition: 10.3% due to parents' consent refusal and absence on assessment days</p>	<p>3 months: ↓ Dietary fat intake for adolescents in the general school treatment group who reported reading the intervention messages ($p < .05$); NS in technical-vocational students</p> <p>Gender: ↓ Dietary fat in girls in technical-vocational school treatment group</p> <p>Other: 53.6% of students reported reading the fat intake recommendations; 37.5% were positive about using the recommendations</p>
Mangunkusumo (2007) [33] Positive	7th grade 9–12 years Dutch n = 469	<p>Purpose: Promote F/V consumption in middle-school students</p> <p>Intensity: One Internet session plus 5-minute in-person counseling session</p> <p>Design: RCT; Internet-based; two-component intervention: (1) computer-tailored nutrition advice and (2) dietary counseling session with school nurse and one parent 2 weeks after Internet session; 30 classes recruited from two cities; computerized questionnaires on F/V intake and determinants of intake; Nurse could access each child's online data</p> <p>Power analysis: Adequately powered</p> <p>Follow-up: 3 months</p> <p>Intervention: Participants received information to increase knowledge of recommended intake levels, increase awareness of individual intake levels, encourage children to like F/V by trying different types of F/V, and stimulate the availability of F/V at home by requesting F/V from parent(s); tailored feedback appeared immediately after completion of computerized questionnaire for treatment group; counseling session to increase knowledge and awareness of intake levels, motivate child to increase F/V intake, involve family in process of behavioral change</p>	<p>3 months: NS for F/V intake between both groups</p> <p>Other: Intervention participants three times more likely to be aware of inadequate personal intake of fruit (OR, 3.04, 95% CI, 1.75, 5.26) and 2.7 times more likely to know the recommended amount of vegetables (OR, 2.71, 95% CI, 1.79, 4.11); 84% of participants reported reading the intervention material; 91% of the intervention sample completed the counseling session</p>

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Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
Casazza (2007) [26] Neutral	9th–12th grade 13–18 years n = 275	Control: No intervention Attrition: 5.3% by post-test due mainly to illness Purpose: Compare computer versus traditional delivery method of intervention to improve diet and exercise in adolescents Intensity: Five 45-minute sessions; 16 weeks Design: CD-ROM program; quasi-experimental; three test groups: computer-based instruction, traditional (lecture-based) instruction, and control; three schools recruited, one for each test group; pre- and post-assessments collected by trained individuals; two 24-hour recalls on two nonconsecutive days at both pre- and post-test; traditional instruction adapted from CD-ROM program and delivered by the principal investigator Power analysis: Adequately powered Follow-up: None Intervention: Study guide and answer key provided to students to reinforce education with each lesson followed by a five-question evaluation	Postintervention: ↓ BMI in computer intervention group ($p < .001$); ↑ nutrition knowledge with both computer ($p < .001$) and traditional instructions ($p = .003$), NS between two groups; ↑ physical activity scores in computer intervention group ($p = .005$); ↓ total calories with both computer ($p = .006$) and traditional instructions ($p = .009$), NS between two groups; ↓ dietary fat in computer intervention group ($p < .001$) Other: Less meals skipped in computer intervention group ($p = .001$); ↑ perceived dietary social support ($p < .001$) and self-efficacy in both intervention groups, NS between groups
Mauriello (2010) [24] Positive	9th–11th grade 13–18 years n = 1,182	Control: No intervention Attrition: 11.6% by postintervention Health in Motion Purpose: Promote energy balance behaviors in high-school-aged adolescents to prevent obesity Intensity: Three 30-minute sessions; 2 months Design: RCT; Internet-based; TTM; eight high schools recruited from four states; three intervention sessions at baseline, 1 month, and 2 months; database of 300 feedback messages at baseline and 33,000+ at follow-up Power analysis: Adequately powered Follow-up: 4 and 10 months Intervention: Targeted three behaviors: (1) ≥60 minutes of physical activity 5 days/week; (2) ≥5 servings of F/V every day; (3) ≤2 hours television each day; stage-matched feedback; computer-tailored feedback based on computerized assessments; full tailoring for physical activity provided feedback on all appropriate constructs for a stage of change; optimal tailoring for F/V and television that only included the perceived benefits of changing and the most important strategies for changing that behavior; audio, video, animations, voiceover included	Postintervention: ↑ Days of physical activity that lasted 60+ minutes in the treatment group ($p < .01$); ↑ servings of F/V in the treatment group ($p < .001$); ↑ movement to action/maintenance stage for physical activity ($p < .001$) and F/V ($p < .01$) in the treatment group; ↑ movement to action/maintenance stage for limiting television ($p < .05$) in the treatment group 4 months: ↑ Servings of F/V in the treatment group ($p < .001$); ↑ movement to action/maintenance stage for F/V ($p < .01$) in the treatment group; 10 months: ↑ Servings of F/V in the treatment group ($p < .001$); progress in physical activity behavior led to progress in F/V intake ($p < .01$) Other: NS for hours of television between groups; ↓ intervention participants in pre-action stage for all behaviors ($p < .001$)
Maes (2011) [25] Negative	12–17 years Multiple European countries n = 558	Control: No intervention Attrition: 34.3% by 10-month follow-up HELENA Food-O-Meter Purpose: Improve diet and eating habits in adolescents across Europe Intensity: Two sessions; 1 month Design: RCT; Internet-based; computerized FFQ for dietary intake; food composition database; decision tree for tailored feedback of fiber, vitamin C, calcium, iron, fat, and beverages; introduction page collects data on age, gender, height, weight, signs of eating disorders; each country could adapt the 137 food item database to include country-specific items; six European cities served as study centers; compared gender and weight status Power analysis: None Follow-up: 2 months Intervention: Students received intervention at baseline and 1 month; researchers and teachers guided students through the program; tailored feedback for target nutrients displayed on screen in	1 month: ↑ Vitamin C in overweight students in the treatment group; no change in fat intake in the treatment group versus increase in control ($p = .029$) 2 months: ↓ Percentage energy from fat in overweight students in the treatment group ($p = .02$) Other: Control group thought advice was “too long” ($p = .002$); intervention group thought advice was personal ($p < .001$) and did not “contain enough information” ($p = .008$)

Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
Ezendam (2012) [35] Positive	12–13 years Dutch n = 759	<p>tabular form and compared with recommended intake; “thumbs-up” or “thumbs-down” symbolized whether or not nutrient intake was within recommended range; advice to correct intake given with “thumbs-down” results; additional statement encouraging students to give feedback to those who can help them change their eating habits</p> <p>Control: Generic standard advice in text format over similar topics at baseline and 1 month</p> <p>Attrition: Approximately 45% from baseline to 2-month follow-up across all study centers</p> <p>FATaintPHAT</p> <p>Purpose: Weight maintenance, improve diet, and increase physical activity</p> <p>Intensity: Eight 15-minute sessions; 10 weeks</p> <p>Design: RCT; Internet-based; theory of planned behavior, precaution adoption process, implementation intentions; 20 schools recruited to study; complete case and intention-to-treat analyses; “at-risk” intervention group defined as normal or overweight or not meeting recommendations</p> <p>Power analysis: None</p> <p>Follow-up: 4 and 24 months</p> <p>Intervention: Goals are to reduce SSBs and energy dense snacks and increase F/V and whole wheat bread, reduce screen time, and increase physical activity; each module included education about the link between behavior and health, assessment, and feedback of behavior and determinants of behavior, and an option to create an implementation intention for a specific goal; participants received normative and comparative feedback, decisional balance information to change attitudes, instructions to identify barriers, and improve self-efficacy and social support</p> <p>Control: No intervention</p> <p>Attrition: 14% by 24-month follow-up due mainly to leaving school or missing measurements</p>	<p>4 months: Intervention participants half as likely to drink >400 ml of SSBs (OR, .54, 95% CI, .34, .88); ↓ snack intake in all students and at-risk group; ↑ fruit intake in at-risk group; ↑ vegetable intake in all students and at-risk group; at-risk group less likely to be in extracurricular sports (OR, .43, 95% CI, .24, .85); ↓ step count in treatment group for all students and at-risk group</p> <p>24 months: NS between groups for SSBs, snacks, F/V intake, whole wheat bread, or sports; NS between groups for BMI, weight, or waist circumference; ↑ step count for at-risk treatment group</p> <p>Other: Intention-to-treat analysis showed: ↑ fruit intake for at-risk group ($\beta = .26$, 95% CI, .01–.51) and NS results for step count at 4- and 24-month follow-ups</p>
Whittemore (2013) [27] Positive	9th–12th grade Diverse n = 366	<p>HEALTH[e]TEEN/HEALTH[e]TEEN + CST</p> <p>Purpose: Promote healthy eating and physical activity to prevent adolescent overweight and obesity; comparison of intervention with CST versus unmodified intervention</p> <p>Intensity: 8–12 sessions</p> <p>Design: Randomized without control; Internet-based; social learning theory; three high schools recruited from two cities; two schools provided intervention during school, one school made it an at-home intervention; teachers instructed to encourage completion of lessons and self-monitoring sections; height and weight taken by trained personnel; compared age, gender, ethnicity, weight, and program usage</p> <p>Power analysis: Inadequately powered, needed n = 392</p> <p>Follow-up: 3 and 6 months</p> <p>Intervention: Eight lessons covered nutrition, physical activity, metabolism, and portion control; tailored feedback via online assessments; reality television concept of program provided videos, text, and lesson commentary from diverse characters as part of social modeling; health coaching and social networking provided individualized feedback and social persuasion; online food and physical activity logs with graphs of progress; program also included</p>	<p>NS between groups for any outcomes, yet improvements within both groups (see 6-month results)</p> <p>6 months: ↑ Self-efficacy for diet and physical activity ($p < .001$); ↑ healthy eating behavior ($p < .001$); ↑ fruit and vegetable intake ($p < .001$); ↑ moderate-to-vigorous exercise ($p < .001$); stretching exercises ($p < .01$); ↓ SSBs ($p < .001$); ↓ junk food intake ($p < .01$); ↓ sedentary behavior ($p < .001$)</p> <p>Gender: Girls improved breakfast intake ($p = .02$) and reduced junk food ($p < .001$)</p> <p>Other: Intervention + CST participants completed fewer lessons ($p = .001$) but completed self-monitoring more so than unmodified intervention group ($p < .001$); less increase in weight ($p = .03$) and BMI ($p = .05$) for at-home group versus in-school group; moderate-to-vigorous physical activity better for completers ($p = .005$)</p>

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Table 1
Continued

Author (year) Quality rating	Sample ^a	Intervention description	Results (intervention vs. control)
		a blog by a "coach" (graduate nursing student), the ability to interact with the coach and other students, and personal online journal; intervention with coping skills included all of the above plus four lessons on stress reduction, conflict resolution, assertive communication, and problem solving regarding healthy eating and physical activity Attrition: 4.7% by 6-month follow-up	

BMI = body mass index; CI = confidence interval; CST = coping skills training; FFQ = food frequency questionnaire; F/V = fruit and vegetable; NS = not significant; OR = odds ratio; RCT = randomized controlled trial; SSB = sugar-sweetened beverages; TTM = transtheoretical model.

^a Sample size listed is postattrition.

^b Follow-up is displayed as time, in months, since postintervention assessment.

^c Saelens BE, Sallis JF, Wilfley DE, Patrick K, Cella JA, Buchta R. Behavioral weight control for overweight adolescents initiated in primary care. *Obes Res.* 2002; 10:22–32.

^d Craighead LW. *The appetite awareness workbook: How to listen to your body and overcome bingeing, overeating & obsession with food.* Oakland, CA: New Harbinger Publications; 2006.

4-month follow-up, at the 2-year follow-up, the intervention did not prevent weight gain.

Jones et al. [23] confirmed via completer and intention-to-treat analyses that, from baseline to the 5-month follow-up, intervention participants decreased their BMI ($p < .01$) and BMI z-score ($p < .01$) compared with control. Additionally, both analyses showed a decrease in the intervention group's number of objective and subjective binge-eating episodes at post-treatment and follow-up (completer: $p < .001$; intention-to-treat: $p < .05$). Only completer analysis indicated that the intervention group decreased their weight/shape concerns from baseline to follow-up (I: -0.49 , $n = 52$; C: -0.21 , $n = 35$).

Randomized controlled trials for healthy eating ($n = 6$). Two RCTs conducted by Haerens et al. [34,36] resulted in short-term [34] and long-term [36] decreases in dietary fat intake, with gender differences favoring female participants in both studies. In one study [36], there were no differences in water, SSB, or fruit intake.

Mauriello et al. [24] showed an increase in F/V (I: $+1.61$ servings/day; C: $+0.57$ servings/day) that was sustained for 10 months after the intervention. Postintervention, the treatment group reported more days with ≥ 60 minutes of physical activity (I: 3.38 days; C: 2.72 days). However, no change in percent overweight was eventually found.

Results from Chen et al. [29] found that a higher number of adolescents in the intervention group increased their F/V intake ($p = .001$) and physical activity ($p = .01$) and nutrition and physical activity knowledge ($p = .001$ and $p = .008$, respectively) and decreased their waist-to-hip ratio ($p = .02$) and diastolic blood pressure ($p = .02$) up to the 6-month follow-up.

Mangunkusumo et al. [33] assessed post-test evaluations 3 months after baseline, and no outcomes produced significant results. Maes et al. [25], at postintervention and 2-month follow-up, reported no significant changes in the percentage of dietary fat (I: $+0.46\%$, $n = 381$; C: $+0.47\%$, $n = 240$).

Quasi-experimental trials ($n = 4$). After modifications to a previous trial [30], which showed a decreasing trend in fat intake and gender differences favoring females, Frenn et al. [31] confirmed a small but significant decrease in the percentage of dietary fat (I: -0.8% , $n = 40$; C: $+0.1\%$, $n = 49$).

Using two 24-hour dietary recalls, Casazza et al. [26] recorded no difference between groups in fat, saturated fat, F/V, or fiber intake from baseline to post-test. However, the results of a food frequency questionnaire showed a significant decrease in fat intake in the computer-based instruction group (I) when compared with lecture-based instruction (L) and control groups (I: -33.5 g/day; L: -13.7 g/day; C: -7.4 g/day). Students in the computer-based instruction group also showed the greatest decrease in BMI (I: -0.20 kg/m²; L: -0.10 kg/m²; C: $+0.20$ kg/m²) and the greatest increase in their physical activity as indicated by a physical activity score. Nutrition knowledge, social support, and self-efficacy increased in both the computer-based and lecture-based groups with no significant difference between groups.

Di Noia et al. [32] reported an increase in daily F/V intake (I: $+0.71$ servings/day, $n = 117$; C: -0.08 servings/day, $n = 390$) and an increase in scores related to perceived benefits of eating F/V (I: 51.80; C: 49.21) in the intervention group. Perceived barriers and self-efficacy showed no difference between groups.

Randomized clinical trial without concurrent control ($n = 1$). Whittemore et al. [27] found that, although there was no difference between two intervention groups with and without coping skills training, both groups improved in several areas by the 6-month follow-up. There was an increase in self-efficacy scores for healthy diet ($+1.1$) and physical activity ($+0.7$), total health eating behavior score ($+3.9$), daily F/V intake ($+0.5$ servings/day), moderate physical activity ($+0.5$ days/week of 30 minutes), and vigorous physical activity ($+0.7$ days/week of 20 minutes). In addition, there was a decline in daily SSB intake (-0.7 servings/day), daily junk food intake (-0.4 servings/day), and sedentary behavior on the weekdays (-0.7 hours/day) and weekends (-0.8 hours/day). Gender and program usage were the only significant moderators of outcomes for healthy eating, sedentary behavior, and physical activity.

Impact of intervention characteristics on nutrition- and obesity-related outcomes

The following intervention characteristics were identified as mediating variables with potential to affect the programs' outcomes: duration, participation, setting, theory of health behavior,

skill-building strategies, parental involvement, and gender. These characteristics are also foundations of program development, and their investigation will enhance future program efficacy.

Duration. Lengths of programs that reported significant positive effects during the intervention and at least one follow-up assessment ($n = 8$) [23,24,27–29,34–36] averaged 6.5 sessions with a 52-lesson outlier removed [28]. Sessions ranged from a one-time 50-minute computer-facilitated fat intake intervention [34] to a 16-session trial for weight management [23]. All sessions lasted between 15 minutes and 1 hour.

Participation. Participant participation was variable. For example, Jones et al. [23] showed successful weight maintenance at the 5-month follow-up, yet noted that only 27% of participants logged in for more than 8 weeks of the 16-week program and 31% never logged on. Haerens et al. [34] noted that 25% of students did not read the intervention messages.

Setting. Five studies were conducted outside of school, whereas 10 were in-school interventions. Programs for weight loss were conducted outside of school, while in-school interventions focused on a targeted nutrient or healthy lifestyle. Nonschool interventions found significant effects on nutrition-related outcomes [29,32] as well as suffered from poor maintenance postintervention [22,28]. Similarly, some in-school interventions had positive effects for nutrition-related outcomes [24,26,27,34], whereas others had little to no influence [25,33]. Setting, surprisingly, did not seem to make a difference in regard to adherence/attrition. One nonschool intervention showed high recruitment and low attrition (8%) [32], whereas the remaining nonschool interventions recruited relatively small samples and had low and high attrition rates ranging from 7.4% to 30%. In-school programs also displayed both low and high attrition rates (from 3.5% up to 50%), although with larger sample sizes. Low participation was recorded in both settings as a failure to read nutrition feedback [22,33,34], incompleteness of intervention modules [23,27,30,31,36], or lack of logging on to the Web site [23,28].

Theory of health behavior. The prevailing theories were the transtheoretical model (TTM) [38] and the theory of planned behavior [39], applied either alone or within a multitheory approach. Of the eight programs with significant positive changes during and after the intervention, 75% utilized a theoretical framework [24,27,29,34–36]. Of the five programs with significant results at post-test only, 60% used a theory of health behavior [31,32]. Of the two remaining programs that led to no significant changes in their sample, neither applied a theory of health behavior [25,33].

Skill-building strategies. Various methods to improve health behavior skills were applied with commonalities being the use of coping [23,27,29,32], consciousness raising [24–36], self-reevaluation [23,30–32], goal setting [23,27,29,32,35], self-monitoring [22,23,27–29], barrier identification [23,28,32,35], problem-solving [22,23,27–29], and building social support [22–25,27–32,34,35]. The application of each skill differed between interventions; however, it was common to use computer-tailored feedback for consciousness raising [24–36], online discussion forums to create an area of social support [22,23,31] and online journals and/or graphs for self-monitoring and goal setting

related to dietary intake [22,23,27,28], weight [22,28], and physical activity [22,23,27–29]. Of the eight programs with significant positive changes both during and after the intervention, 13% used self-reevaluation [23], 38% coping [23,27,29], 38% barrier identification [23,28,35], 50% problem solving [23,27–29], 50% goal setting [23,27,29,35], 50% self-monitoring [23,27–29], 88% consciousness raising [24–26], and 88% used social support [23–35].

Parental involvement. Seven studies involved parents, by providing educational materials to parents [22,23,31,33,36], by having a parent attend a counseling session with the child [33], or by including parents as independent study participants with separate access to the intervention Web site [28,29]. However, only one evaluated the influence of parent participation on the adolescents' outcomes in comparison with a control with no parental involvement. Haerens et al. [27] concluded that parental involvement aided in the decrease of girls' fat intake by the end of the first year compared with a nonparental control, yet at the 2-year evaluation, no significant differences were seen between the interventions with and without parental support.

Gender. Gender differences became apparent in four studies [27,30,34,36]; however, not all studies evaluated their results based on gender. Within those studies, gender-based dietary changes occurred in females. Doyle et al. [22] implemented the StudentBodies-2 web-based program, which used gender-specific interfaces and content, for example, masculine/feminine color schemes and gender-specific media portrayals of attractiveness, yet their outcomes were not separated by gender, and there was no mention of this aspect's impact on results.

Discussion

Because computer-based nutrition programs are relatively new, it is not surprising that few studies or reviews have been published in this area specifically for adolescents. Previously, a review by An et al. [40] concluded that web-based interventions demonstrated the potential to decrease childhood obesity, albeit after the consideration of more rigorous methodologies, appropriately implemented theoretical frameworks, increased long-term effectiveness, and gender-appropriate interventions. Another review by Nguyen et al. [41] concluded that poor study quality and evaluation obstructed a clear viewpoint about the effectiveness of electronic interventions in this population, despite over 70% of studies reporting positive obesity-related outcomes. Whiteley et al. [42] determined that while results of some Internet-based interventions were positive, a lack of randomization, insufficient number of youth, and length of intervention were areas that should be addressed in future research. In addition, Tate [43] determined that although interventions thus far have been feasible and initially successful, future programs should consider the influence of setting, how to make the programs more engaging to youth and creating designs that account for user preferences and patterns of use.

This systematic review differs from previous reviews in that it allows for multiple study designs, rather than restricting by intervention design [40,43]. It concentrates on stationary computer-based methods of nutrition education, both Internet and CD-ROM, rather than only the Internet [40,42] or all electronic methods of delivery [41,43]. Additionally, this review focuses on stand-alone computer programs, whereas previous reviews included interventions that used the computer only as

an adjunct component [43]. This review concentrates specifically on the adolescent population, whereas prior reviews included children and adolescents. Three of the four previous reviews were published 4–5 years ago, meaning their sample was even older; over half of the present sample was published within the last 5 years, meaning this review includes previously unavailable data. Although the overlap of studies between reviews is small, some conclusions are similar because evaluation of these interventions is in its early stages. Similar conclusions between this review and previous reviews are the need for more rigorous methodology, application of health behavior theory, and the investigation of gender, duration, long-term maintenance, and engagement. In addition to previous findings, our additional conclusions and recommendations are useful to both nutrition researchers and practitioners in developing and improving the application of computer-based methods.

Conclusions and Recommendations

Comparison with face-to-face interventions needed

One recent study [44] found web-based programs to be as effective as face-to-face programs for low-income adults, and a similar comparative study would be useful for adolescents. One of the interventions in this review [26] included such a comparison and demonstrated that a computer-based nutrition intervention was equally as effective as a lecture-style intervention delivering the same information. Additional comparisons, especially with short-term and long-term follow-up assessments, would also prove useful to compare the extent to which computer-mediated interventions could equal face-to-face interventions in terms of behavior change and maintenance.

Use of behavior theories supported

Although using a theory of health behavior within nutrition interventions has been supported, much discussion has emerged on how to use theory and which theory to use [45]. Although 60% of interventions applied a theoretical framework(s), we could not conclude that any particular theory led to better outcomes; we can only recommend using a theory/model of health behavior rather than none. Application of the appropriate theory will most likely depend on the intervention, the outcomes, and mediating variables [46].

Ritterband et al. [47] underscored the importance of applying a behavior change model to Internet interventions and emphasized that intervention content and characteristics should be considered as part of the model for behavior change, for example, delivery of content (audio, video, animations, graphics), appearance, burdens of using the Web site (difficult navigation and intervention too long), and message style (text vs. animations). For instance, in a process evaluation of an online weight loss program for adults [48], the investigators were surprised that social support features were disliked and not used by participants, even though social support has been shown to be important to in-person programs. In another evaluation of a nutrition-related Web site for adults [49], simple activities for making a healthy plate were used much more often than more complex activities involving carbohydrate counting, and participants returned to “make a plate” until they received correct scores. Therefore, computer program characteristics play a key role in behavior

change and should be considered along with traditional behavior change methods.

Methods to ensure adherence and engagement needed

Researchers should be concerned with factors regarding usage and adherence, including user expectations and support, which will help us to understand their role in developing the appropriate program intensity. Aligned with these considerations, interventions within our sample included such elements as e-mail counseling [28], gender-specific interfaces [22], multimedia interaction [24,27,29], and computer-tailored feedback [24–36] to increase adherence and engagement through contact, personalization, and entertainment. In adults, computer-tailored feedback in nutrition education has been successful [50,51], as has the use of e-counseling [52,53]. In our review, computer-tailoring was associated with significant positive outcomes. More common application of these methods and further evaluation will bring us closer to understanding their impact on participation and, consequently, nutrition-related outcomes.

Parental role to be clarified and evaluated

There was insufficient evidence to conclude the influence of parental involvement. Compared with children, there is less evidence that supports the inclusion or participation of parents as an important component of nutrition education interventions for adolescents, particularly for computer-mediated interventions. A 2006 meta-analysis [54] of obesity prevention programs for children and adolescents found that parental involvement did not significantly improve intervention effects compared with other more influential factors, for example, gender and program length; however, the review did not exclusively evaluate computer interventions. In contrast, Hingle et al. [55], based on a systematic review of parental involvement in child and adolescent dietary interventions, suggested that *direct* methods of parental involvement tended to result in better outcomes than the more common *indirect* methods. Family-oriented clinical interventions have demonstrated significant effects on weight and dietary outcomes [56,57], and it has been shown that parental restrictions of unhealthy foods may help reduce consumption of these foods in adolescence [58]. However, for computer-based nutrition interventions for adolescents, it is unclear at present if this is an important component for success. The dynamic of the parent–adolescent interaction may differ when considering computer-mediated nutrition interventions, as the *adolescent* is considered the primary food chooser and not the *parent*.

Careful justification of nutrition outcomes needed

Choosing the optimal nutrition-related outcomes is also important. Although the USDA NEL concluded that there is moderately strong support that dietary energy density is associated with childhood adiposity [59], none of the interventions addressed dietary energy density. There was limited support for F/V intake as a protective measure of adiposity in children [59]; however, seven studies addressed F/V intake. The USDA NEL found moderate support that dietary fat was associated with childhood adiposity [59], and seven studies accordingly addressed dietary fat. Adolescents are the highest consumers of SSB, which are an important contributor of calories in the diet [60–62]. The USDA

NEL concluded that strong evidence existed for the association between SSB and increased childhood adiposity [59]. However, only three studies in this review addressed SSB intake. Addressing the identified dietary factors in nutrition interventions is a priority for decreasing the overall prevalence of overweight and obesity in adolescents.

Targeting weight maintenance rather than weight loss

Also to be considered is targeting weight maintenance rather than weight loss and methods of measuring the weight outcomes for computer-based interventions. Fowler-Brown et al. [63] emphasized that weight maintenance rather than weight loss should be considered for any obese or overweight child above age two without medical complications. Weight stabilization methods, for example, portion control, decreases in fat and sugar, and controlling binge eating, may prove a more effective goal via computer-based instruction in this population, especially for long-term maintenance. Adolescents are growing and weight gain is normal; however, excess weight gain should be prevented. Therefore, it will be important for weight maintenance interventions to decipher between normal weight gain and excessive weight gain when determining intervention effects. For example, the intervention by Ezendam et al. [35] reported that it did not prevent weight gain in the intervention group; however, the authors did not state whether the weight gain or the rate of weight gain at the 2-year follow-up was normal or excessive. This distinction will help determine which weight gain prevention interventions effectively prevent future overweight.

Need to adjust body mass index during puberty

Of the articles measuring BMI ($n = 7$), only two mentioned using Tanner scores or correcting for pubertal status when analyzing BMI. For adolescents up to age 20, the BMI is appropriately standardized according to gender and age to account for growth [64] but not for those of pubertal age. Therefore, the sexual maturation stage must also be taken into account when assessing the risk of obesity during the age when pubertal changes are taking place [65].

More research on optimal program intensity needed

Optimal intensity of a computer-based nutrition intervention, which consists of dose and duration, could not be concluded due to fidelity to treatment issues and varying program lengths, outcome measures, and results. Suggestions for optimal program duration have been given. Connell et al. [66] suggested that at least 50 hours of in-school instruction was adequate to produce behavior change; Sharma [67], based on a review of in-school obesity prevention programs for Kindergarten to 12th grade, recommended that dietary interventions last at least 6 months. However, both reviews considered only in-school, noncomputer interventions. Therefore, it is clear that appropriate program intensity requires further investigation, keeping in mind that computer-mediated instruction may have substantially different requirements.

Gender differences in outcomes to be researched

Both computer-mediated and traditional interventions have experienced gender-based differences in outcomes, especially

dietary outcomes. *Planet Health*, a 2-year intervention for middle-school students, was able to increase F/V consumption in girls but not in boys [68]. The same trend in favor of better outcomes for girls can be found in traditional interventions that cater to younger children as well [69–71]. However, no gender differences were found in nutrition knowledge when active versus passive Web sites were compared in middle-school students [72]. In the current review, gender differences were found in three studies; however, evaluation based on gender in other studies may have produced additional insight. Paying closer attention to gender-specific learning styles, preferences, or expectations for weight loss or weight management could help improve nutrition-related outcomes in future investigations.

Summary and Implications

Based on the concerns apparent in our review and similar reviews, important issues to be addressed in future research include (1) replication of studies that measure dietary energy density, F/V, dietary fat, and SSB; (2) rigorous methodology, including power analyses, randomization, and comprehensive reporting of the intervention and components; (3) inclusion of long-term maintenance strategies and evaluation; (4) attention to Web site characteristics, participation, and adherence; (5) the inclusion of a theoretical framework for behavioral change; (6) direct methods of parental involvement, if any, and evaluation of such methods; (7) investigation of gender-specific programs; and (8) comprehensive recording of dose and duration for future comparison. With all its advantages, computer-based nutrition education programs have the potential to persuade adolescents to improve overall dietary habits and curb the expansion of overweight and obesity. However, their results at present specify that further research is necessary in order to achieve their full potential.

References

- [1] Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009–2010. *NCHS Data Brief* 2012;1–8.
- [2] Eaton DK, Kann L, Kinchen S, et al. Youth risk behavior surveillance – United States, 2011. *MMWR Surveill Summ* 2012;61:1–162.
- [3] Ogden CL, Carroll M. Prevalence of obesity among children and adolescents: United States trends 1963–1965 through 2007–2008. Centers for Disease Control and Prevention Web site. Available at: http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm. Updated 2010. Accessed November 15, 2012.
- [4] Alton I. The overweight adolescent. In: Stang J, Story M. eds. *Guidelines for adolescent nutrition services*. Center for Leadership, Education and Training in Maternal and Child Nutrition, Division of Epidemiology and Community Health, School of Public Health, University of Minnesota. Minneapolis, MN; 2005: Chapter 7.
- [5] Pan L, Sherry B, Park S, Blanck HM. The association of obesity and school absenteeism attributed to illness or injury among adolescents in the United States, 2009. *J Adolesc Health* 2013;52:64–9.
- [6] Gopinath B, Baur LA, Burlutsky G, Mitchell P. Adiposity adversely influences quality of life among adolescents. *J Adolesc Health* 2013;52:649–53.
- [7] Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006;1:11–25.
- [8] Dietz WH. Critical periods in childhood for the development of obesity. *Am J Clin Nutr* 1994;59:955–9.
- [9] Roseman MG, Riddell MC, Haynes JN. A content analysis of kindergarten–12th grade school-based nutrition interventions: Taking advantage of past learning. *J Nutr Educ Behav* 2011;43:2–18.
- [10] Witt EA, Massman AJ, Jackson LA. Trends in youth's videogame playing, overall computer use, and communication technology use: The impact of self-esteem and the Big Five personality factors. *Comput Hum Behav* 2011; 27:763–9.

- [11] Teen and young adult internet use. Pew Research Center web site. Available at: <http://www.pewresearch.org/millennials/teen-internet-use-graphic/>. Accessed November 15, 2012.
- [12] Gray L, Thomas N, Lewis L. Teachers' use of educational technology in U.S. public schools: 2009. Washington, D.C.: National Center for Education Statistics. Institute of Education Sciences. U.S. Department of Education; 2010:2010–40. NCEES.
- [13] File T. Computer and internet use in the United States. U.S. Department of Commerce Economics and Statistics Administration. U.S. Census Bureau. Washington, D.C.: Current Population Survey Reports; 2013:P20–569.
- [14] Hutton HE, Wilson LM, Apelberg BJ, et al. A systematic review of randomized controlled trials: Web-based interventions for smoking cessation among adolescents, college students, and adults. *Nicotine Tob Res* 2011;13:227–38.
- [15] Lightfoot M, Comulada WS, Stover G. Computerized HIV preventive intervention for adolescents: Indications of efficacy. *Am J Public Health* 2007;97:1027–30.
- [16] Schinke SP, Schwinn TM, Fang L. Longitudinal outcomes of an alcohol abuse prevention program for urban adolescents. *J Adolesc Health* 2010;46:451–7.
- [17] Schwinn TM, Schinke SP. Preventing alcohol use among late adolescent urban youth: 6-year results from a computer-based intervention. *J Stud Alcohol Drugs* 2010;71:535–8.
- [18] Roberto AJ, Zimmerman RS, Carlyle KE, et al. The effects of a computer-based pregnancy, STD, and HIV prevention intervention: A nine-school trial. *Health Commun* 2007;21:115–24.
- [19] Paperny DM, Starn JR. Adolescent pregnancy prevention by health education computer games: Computer-assisted instruction of knowledge and attitudes. *Pediatrics* 1989;83:742–52.
- [20] United States Department of Agriculture. Nutrition evidence library research design and implementation checklists. United States Department of Agriculture Web site. Available at: <http://nutritionevidencelibrary.gov/topic.cfm?cat=3232>. Updated 2010. Accessed July 20, 2012.
- [21] US Department of Agriculture, 2010 Dietary guideline Advisory Committee. 2010 DGAC conclusion grading chart. US Department of Agriculture web site. Available at: <http://nutritionevidencelibrary.gov/topic.cfm?cat=3210>. Updated 2010. Accessed July 20, 2012.
- [22] Doyle AC, Goldschmidt A, Huang C, et al. Reduction of overweight and eating disorder symptoms via the internet in adolescents: A randomized controlled trial. *J Adolesc Health* 2008;43:172–9.
- [23] Jones M, Luce KH, Osborne MI, et al. Randomized, controlled trial of an internet-facilitated intervention for reducing binge eating and overweight in adolescents. *Pediatrics* 2008;121:453–62.
- [24] Mauriello LM, Ciavatta MM, Paiva AL, et al. Results of a multi-media multiple behavior obesity prevention program for adolescents. *Prev Med* 2010;51:451–6.
- [25] Maes L, Cook TL, Ottovaere C, et al. Pilot evaluation of the HELENA (healthy lifestyle in Europe by nutrition in adolescence) food-O-meter, a computer-tailored nutrition advice for adolescents: A study in six European cities. *Public Health Nutr* 2011;14:1292–302.
- [26] 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.
- [27] Whittemore R, Jeon S, Grey M. An internet obesity prevention program for adolescents. *J Adolesc Health* 2013;52:439–47.
- [28] Williamson DA, Walden HM, White MA, et al. Two-year internet-based randomized controlled trial for weight loss in African-American girls. *Obesity (Silver Spring)* 2006;14:1231–43.
- [29] Chen JL, Weiss S, Heyman MB, et al. The efficacy of the web-based childhood obesity prevention program in Chinese American adolescents (Web ABC study). *J Adolesc Health* 2011;49:148–54.
- [30] Frenn M, Malin S, Bansal N, et al. Addressing health disparities in middle school students' nutrition and exercise. *J Community Health Nurs* 2003;20:1–14.
- [31] Frenn M, Malin S, Brown RL, et al. Changing the tide: An Internet/video exercise and low-fat diet intervention with middle-school students. *Appl Nurs Res* 2005;18:13–21.
- [32] Di Noia J, Contento IR, Prochaska JO. Computer-mediated intervention tailored on transtheoretical model stages and processes of change increases fruit and vegetable consumption among urban African-American adolescents. *Am J Health Promot* 2008;22:336–41.
- [33] Mangunkusumo RT, Brug J, de Koning HJ, et al. School-based internet-tailored fruit and vegetable education combined with brief counseling increases children's awareness of intake levels. *Public Health Nutr* 2007;10:273–9.
- [34] Haerens L, Deforche B, Maes L, et al. A computer-tailored dietary fat intake intervention for adolescents: Results of a randomized controlled trial. *Ann Behav Med* 2007;34:253–62.
- [35] Ezendam NP, Brug J, Oenema A. Evaluation of the web-based computer-tailored FATaintPHAT intervention to promote energy balance among adolescents: Results from a school cluster randomized trial. *Arch Pediatr Adolesc Med* 2012;166:248–55.
- [36] Haerens L, Deforche B, Maes L, et al. Evaluation of a 2-year physical activity and healthy eating intervention in middle school children. *Health Educ Res* 2006;21:911–21.
- [37] Williamson DA, Martin PD, White MA, et al. Efficacy of an internet-based behavioral weight loss program for overweight adolescent African-American girls. *Eat Weight Disord* 2005;10:193–203.
- [38] Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. *Am J Health Promot* 1997;12:38–48.
- [39] Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process* 1991;50:179–211.
- [40] An JY, Hayman LL, Park YS, et al. Web-based weight management programs for children and adolescents: A systematic review of randomized controlled trial studies. *ANS Adv Nurs Sci* 2009;32:222–40.
- [41] Nguyen B, Kornman KP, Baur LA. A review of electronic interventions for prevention and treatment of overweight and obesity in young people. *Obes Rev* 2011;12:e298–314.
- [42] Whiteley JA, Bailey BW, McInnis KJ. State of the art reviews: Using the internet to promote physical activity and healthy eating in youth. *Am J Lifestyle Med* 2008;2:159–77.
- [43] Tate DF. Application of innovative technologies in the prevention and treatment of overweight in children and adolescents. In: Jelalian E, Steele RG, eds. *Issues in clinical child psychology: Handbook of childhood and adolescent obesity*. New York, NY: Springer; 2009. Chapter 23.
- [44] Neuenschwander LM, Abbott A, Mobley AR. Comparison of a web-based vs. in-person nutrition education program for low-income adults. *J Acad Nutr Diet* 2013;113:120–6.
- [45] Brug J, Oenema A, Ferreira I. Theory, evidence and intervention mapping to improve behavior nutrition and physical activity interventions. *Int J Behav Nutr Phys Act* 2005;2:2.
- [46] Cerin E, Barnett A, Baranowski T. Testing theories of dietary behavior change in youth using the mediating variable model with intervention programs. *J Nutr Educ Behav* 2009;41:309–18.
- [47] Ritterband LM, Thorndike FP, Cox DJ, et al. A behavior change model for internet interventions. *Ann Behav Med* 2009;38:18–27.
- [48] McConnon A, Kirk SF, Ransley JK. Process evaluation of an internet-based resource for weight control: Use and views of an obese sample. *J Nutr Educ Behav* 2009;41:261–7.
- [49] Herrejon K, Hartke JL, Scherer J, Chapman-Novakofski K. The creation and impact evaluation of "your guide to diet and diabetes," an interactive web-based diabetes tutorial. *Diabetes Technol Ther* 2009;11:171–9.
- [50] Brug J, Oenema A, Campbell M. Past, present, and future of computer-tailored nutrition education. *Am J Clin Nutr* 2003;77(suppl 4):1028S–34S.
- [51] Oenema A, Brug J, Lechner L. Web-based tailored nutrition education: Results of a randomized controlled trial. *Health Education Res* 2001;16:647–60.
- [52] Brouwer W, Kroeze W, Crutzen R, et al. Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review. *J Med Internet Res* 2011;13:e2.
- [53] Tate DF, Jackvony EH, Wing RR. Effects of internet behavioral counseling on weight loss in adults at risk for type 2 diabetes: A randomized trial. *JAMA* 2003;289:1833–6.
- [54] Stice E, Shaw H, Marti CN. A meta-analytic review of obesity prevention programs for children and adolescents: The skinny on interventions that work. *Psychol Bull* 2006;132:667–91.
- [55] Hingle MD, O'Connor TM, Dave JM, Baranowski T. Parental involvement in interventions to improve child dietary intake: A systematic review. *Prev Med* 2010;51:103–11.
- [56] Epstein LH, Wing RR, Koeske R, Valoski A. Long-term effects of family-based treatment of childhood obesity. *J Consult Clin Psychol* 1987;55:91–5.
- [57] Epstein LH, Valoski A, Wing RR, McCurley J. Ten-year follow-up of behavioral, family-based treatment for obese children. *JAMA* 1990;264:2519–23.
- [58] De Bourdeaudhuij I. Family food rules and healthy eating in adolescents. *J Health Psychol* 1997;2:45–56.
- [59] US Department of Agriculture, US Department of health and Human Services. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans. USDA Center for Nutrition Policy and Promotion Web site. Available at: <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/DGAC/Report/2010DGACReport-camera-ready-Jan11-11.pdf>. Updated 2011. Accessed December 1, 2012.
- [60] Wang YC, Ludwig DS, Sonneville K, Gortmaker SL. Impact of change in sweetened caloric beverage consumption on energy intake among children and adolescents. *Arch Pediatr Adolesc Med* 2009;163:336–43.
- [61] Guthrie JF, Morton JF. Food sources of added sweeteners in the diets of Americans. *J Am Diet Assoc* 2000;100:43–51.
- [62] Chen L, Appel LJ, Loria C, et al. Reduction in consumption of sugar-sweetened beverages is associated with weight loss: The PREMIER trial. *Am J Clin Nutr* 2009;89:1299–306.

- [63] Fowler-Brown A, Kahwati LC. Prevention and treatment of overweight in children and adolescents. *Am Fam Physician* 2004;69:2591–8.
- [64] Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: Methods and development. *Vital Health Stat* 2002;11:1–190.
- [65] Kanbur NO, Derman O, Kinik E. Prevalence of obesity in adolescents and the impact of sexual maturation stage on body mass index in obese adolescents. *Int J Adolesc Med Health* 2002;14:61–5.
- [66] Connell DB, Turner RR, Mason EF. Summary of findings of the school health education evaluation: Health promotion effectiveness, implementation, and costs. *J Sch Health* 1985;55:316–21.
- [67] Sharma M. Dietary education in school-based childhood obesity prevention programs. *Adv Nutr* 2011;2:207S–16S.
- [68] Gortmaker SL, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet health. *Arch Pediatr Adolesc Med* 1999;153:409–18.
- [69] Kelder SH, Perry CL, Lytle LA, Klepp KI. Community-wide youth nutrition education: Long-term outcomes of the Minnesota heart health program. *Health Educ Res* 1995;10:119–31.
- [70] Perry CL, Bishop DB, Taylor G, et al. Changing fruit and vegetable consumption among children: The 5-a-day power plus program in St. Paul, Minnesota. *Am J Public Health* 1998;88:603–9.
- [71] Neumark-Sztainer D, Story M, Resnick MD, Blum RW. Lessons learned about adolescent nutrition from the Minnesota adolescent health survey. *J Am Diet Assoc* 1998;98:1449–56.
- [72] Castelli DM, Goss D, Scherer J, Chapman-Novakofski K. Healthy outcomes for teens project: Diabetes prevention through distributed interactive learning. *Diabetes Technol Ther* 2011;13:359–64.