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The Use of Technology to Promote Nutrition and Physical Activity Behavior Change in Youth: A Review

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ABSTRACT

Background. Overweight and obesity in children and adolescents continues to be a major public health concern in the United States. Innovative strategies are needed to encourage sustained changes in youth behaviors and thereby lower disease risk. A variety of technologies are currently used by youth in everyday life, presenting health professionals and researchers with opportunities to reach youth in real time and to provide them with the knowledge and motivation to engage in positive health behavior change. It is important to explore, identify, and systematically test approaches designed specifically for this population to determine the most effective and acceptable approaches.

Objective. The purpose of this review was to determine the types of technologies that have been used to engage youth in nutrition and physical activity behavior change and characterize the dose of content associated with behavior change.

Methods. Five databases were searched: Pub Med, MEDLINE, Psych Info, ERIC, and the Cochrane Library. Searches were conducted independently by two authors and compared. This review was limited to studies published in English in peer-reviewed scientific journals. Studies were included if they enrolled school-aged children or adolescents, 6 to 19 years of age; evaluated a nutrition and/or physical activity behavior change intervention; used technology as a primary method to deliver the intervention content; and employed a randomized, quasi-experimental, or pre-post design. A coding schema was developed to characterize technology type, intervention dose, and developmental stage of participants for each of the studies.

Results. Reviewers identified 1,522 abstracts, including 62 that met initial inclusion criteria. Twenty two studies met final inclusion criteria. Of these 22 studies, 3 targeted nutrition behaviors only, 8 targeted physical activity behaviors only, and 11 targeted a combination. Four types of technology were used to deliver intervention content and engage participants; web-based applications and computer tailored programs were the most frequently reported types. Duration of intervention programs ranged from 2 to 16 weeks. Ten out of 22 studies reported significant effects on nutrition and/or physical activity behaviors, but the magnitude of behavior change for those studies was extremely modest, and only two studies reported maintenance of behavior changes at follow-up. Process evaluation data were reported in 13 of the 22 studies.

In this issue:

Conclusions. The 22 studies included in this review used varied technology types, study designs, and assessment methods. While the use of technology has been suggested as an acceptable method of engaging youth in prevention activities and short-term behavioral outcomes have been observed, there was insufficient systematic research on the use of technology to promote nutrition and physical activity behavior change in youth to draw a meaningful conclusion. Determining the optimal degree of interactivity between youth, the content, and the interventionists (i.e. "dose") is a crucial next step in order to move this field of research forward.

INTRODUCTION

Obesity in children and adolescents continues to be a major public health concern in the United States, with 17% of youth at or above the 95th percentile of BMI-for-age.[1] A high intake of energy-dense foods[2,3] and a sedentary lifestyle[4,5] are undoubtedly contributing factors to pediatric obesity. Fewer than one-third of youth meet national guidelines for diet and physical activity,[6,7] placing them at increased risk for early morbidity and mortality.[8]

The majority of obesity prevention and health promotion programs designed to impact nutrition and physical activity behaviors in children and adolescents have been implemented in school settings.[9-11] These programs typically elicit only modest and short-term behavior changes;[12] evidence supporting sustained changes beyond the life of any intervention is very limited. Innovative intervention strategies are needed to encourage sustained changes in youth behaviors and thereby lower disease risk. The use of technology to deliver intervention programming presents an opportunity for innovation and an avenue through which to promote healthy lifestyle behavior change in children and adolescents.

Increasingly, technology has become highly sophisticated, mobile, and increasingly integrated into everyday life. Youth are heavy users of technology.[13] In 2012, over 78% of American teens (12-17 years old) carried a mobile device,[14] 95% access the Internet daily, and the average teen sent and received approximately 60 text messages per day.[15] The increasing popularity and widespread use of mobile technologies has presented educators and health professionals with new opportunities to reach the majority of youth who do not participate in traditional (face-to-face) healthy lifestyle programs.

While technology has been used to deliver health information and promote healthy eating and regular physical activity in the research setting,[16] the majority of these programs have been conducted with adult populations. Programs designed for adults may not be directly relevant or directly transferable to children and adolescents, as younger populations may not have the ability or opportunity to act on intervention recommendations. Further, youth may prefer different types of technologies or different interactions with content and may be motivated by different factors than adults. Programs that have been specifically designed to target youth have largely been focused on preventing tobacco use, alcohol use, or risky sexual behaviors[17] or have provided guidance on the management of a disease (e.g. blood sugar monitoring or weight loss),[18-22] rather than prevention of disease through healthy eating and regular physical activity.

The emergence and widespread use of mobile technologies has presented researchers with new challenges and opportunities related to the design, implementation, and evaluation of technology-based interventions. Of particular importance is determining the most effective ways to engage participants with content to elicit health behavior change.

Despite the rapidly advancing platforms, numerous health-related software applications, and the high level of interest within the scientific community regarding 'eHealth' (electronic health) or 'mHealth' (mobile health) approaches to improve youth health behavior,[23-25] systematic research is lacking. With the goal of describing the current state of the evidence and make recommendations for future research to move the field forward, this study sought to determine the types of technologies that have been used to engage youth in nutrition and physical activity behavior change, and when possible, to characterize the dose of content associated with behavior change. When available, data on acceptability and feasibility were also collected.

METHODS

Data sources and search terms
A systematic literature search was conducted to identify studies that sought to change nutrition and physical activity behaviors using eHealth or mHealth approaches to intervention delivery in school-age children and adolescent (6-19 years old). Five databases were searched: Pub Med, MEDLINE, Psych Info, ERIC, and the Cochrane Library. Additional studies were sought using reference lists of retrieved articles, references of review articles, and the authors' files. Searches were conducted separately by two authors and results compared. A chronological limit on the search was not imposed, since it was assumed all studies using technology as part of the intervention delivery would be contemporary. Search terms included e-health, e-intervention, web, computer, e-mail, mHealth, multimedia, Internet, personal digital assistant (PDA), cell phone, mobile phone, video games, exergames, active video games, interactive multimedia, nutrition, physical activity, exercise, obesity prevention, short message service (SMS), text message, behavior change intervention, online, and digital.

Selection criteria
The review was limited to studies published in English in peer-reviewed scientific journals. Studies were included if they met the following criteria: i) enrollment of children or adolescents, 6 to 19 years of age, ii) evaluation of an intervention designed to change nutrition and/or physical activity behavior for the purposes of promoting health and/or preventing obesity, iii) technology used as a primary method to deliver the intervention content, and iv) randomized controlled trial, quasi-experimental, or pre-post design. Studies were excluded if they did not enroll youth within the specified age ranges, were designed to treat a disease or condition (for example, only targeting obese or diabetic youth or treating substance abuse, such as smoking), or explored the feasibility of an approach without evaluating a diet or physical activity outcome.

Data abstraction
During the independent review process, the following information was abstracted from eligible articles and tabulated when available: primary author, year of publication, technology type, participant age, race/ethnicity, socioeconomic status, study design, intervention duration and frequency, results, measurement method of primary outcomes, and process evaluation.

Data coding
Coding schema were developed for the following study characteristics: i) technology type (including web-based applications designed to be accessed through a desktop interface; mobile applications and mobile devices such as cellular phones and PDAs; video or computer games; and "exergames," or video games that require participants to be physically active), ii) intervention dose (duration of the intervention period, duration of each intervention session, and frequency of content delivery or activities), and iii) developmental stage of participants (children 6-11 years; young adolescents, 12-15 years; older adolescents, 16-19 years).

RESULTS

The literature search identified a total of 1,522 abstracts (Pub Med = 462, Medline = 986, ERIC = 66, Psych Info = 8; Cochrane Library = 0). Sixty-two met the initial inclusion criteria. Twenty-two studies met the final inclusion criteria listed above and were included in this review.

Study Design
Four types of study designs were identified: two studies utilized a single group ("uncontrolled") pre-post design;[26,27] nine, two-group, quasi-experimental studies in which schools,[28-31] classrooms,[32] or individuals[33-36] were the units of recruitment and randomization; two studies that used a 2-group quasi-experimental design in schools without randomization;[37,38] and nine randomized controlled trials.[39-47]

Intervention Targets
Of the 22 studies reviewed, three studies targeted nutrition behaviors only[26,30,39] eight studies targeted physical activity behaviors only,[27,36,37,40-44] and eleven studies targeted a combination of nutrition and physical activity behaviors.[28,31-35,38,45-47]

Method of Intervention Delivery – Technology Type
Four types of technology were used to deliver intervention content and engage participants. [Table 1] Web-based applications and computer-tailored programs (n=13 studies) were the most commonly reported method of engagement,[26,28-32,34,38,40,42,45-47] followed by computer games, (n=3)[36,37,48,] SMS/mobile phones, (n=2)[33,44,] and active video games, (n=4).[27,36,41,43]

Table 1

Characteristics of Technology-Based Studies Designed to Impact Physical Activity and Nutrition in Youth, 6-19 Years

Primary Author, Year, Program Name	Participants	Technology Type	Program Duration	Session Duration	Session Frequency	Total Reported Dose (Duration x Frequency)
Baranowski, et al. 2003a,[48] *Squire's Quest*	Children, 6-11 yrs	Health behavior change video game	10 wks	25 min	Weekly	250 min (4.1 hrs)
Baranowski et al. 2011[35] *Escape from Diab, Nanoswarm*	Children, 10-12 yrs	Health behavior change video game	8 wks	40 min	18 sessions	720 min (12 hrs)
Goran, et al. 2005.[37] IMPACT	Children, 6-11 yrs	Health behavior change video game	8 wks	Not specified; total of 12 hrs	Not specified	12 hrs
Baranowski, et al. 2003b,[28] *GEMS*	African-American girls, 6-11 yrs	Web-based application or computer-tailored program	8 wks	Log-on and complete activity	Weekly	Unable to determine
Chen et al. 2011[46]	Chinese American adolescents, 12-15 yrs	Web-based application or computer-tailored program	8 wks	Log on and complete activity	Weekly	Unable to determine
Ezendam et al. 2012[47]	Young adolescents, 12-13 yrs	Web-based application or computer-tailored program	10 wks	15 min	8 sessions	120 min(2 hrs)
Frenn, et al. 2003[29]	Young adolescents, 12-15 yrs	Web-based application or computer-tailored program	16 wks	40 min	4 sessions	160 min (2.67 hrs)
Frenn, et al. 2005,[32] *Changing the Tide*	Young adolescents, 12-15 yrs	Web-based application or computer-tailored program	4 wks	40 min	12 sessions	480 min (8 hrs)
Gorely et al. 2009[38]	Children, 7 -11 yrs	Web-based application or computer-tailored program	10 mo	Not specified	Not specified	Unable to determine
Jago, et al. 2005,[40] *Fit for Life Boy Scout Badge*	Adolescent boys, 12-15 yrs	Web-based application or computer-tailored program	9 wks	Log-on and complete activity	2 times per week	Unable to determine
Long, et al. 2004[30]	Young adolescents, 12-15 yrs	Web-based application or computer-tailored program	4 wks	Not specified; total of 5 hours	Not specified	5 hrs
Long, et al. 2006[26]	Young adolescents, 12-15 yrs	Web-based application or computer-tailored program	3 wks	Not specified; total of 5 hours	Not specified	5 hrs
Marks, et al. 2006,[42] *LifeBytes*	Adolescent girls, 12-15 yrs	Web-based application or computer-tailored program	2 wks	Not specified	4 times	Unable to determine
Mauriello, et al. 2010,[31] *Health in Motion*	Older adolescents, 16-19 yrs	Web-based application or computer-tailored program	8 wks	30 min	3 sessions	1.5 hrs
Thompson, et al. 2008,[34] *Food, Fun, and Fitness*	African-American girls, 6-11 yrs	Web-based application or computer-tailored program	8 wks	Log-on and complete activity	Once per week	Unable to determine
Whittemore et al. 2013[45]	Adolescents, 14-15 yrs	Web-based application or computer-tailored program	8-12 lessons delivered over 3 mo	Log-on and complete activity	Monitored bimonthly	Unable to determine
Baranowski et al. 2012[36]	Children, 9-12 yrs	Active video game or "exergame"	13 wks	Not specified	Not specified	Unable to determine
Mhurchu, et al. 2008,[43] *Couch Potatoes to Jumping Beans*	Young adolescents, 12-15 yrs	Active video game or "exergame"	12 wks	Ad libitum	Unlimited	Unable to determine
Maloney, et al. 2008[41]	Children, 6-11 yrs	Active video game or "exergame"	10 wks	Ad libitum	Unlimited	Unable to determine
Owens et al. 2011[27]	Children, 8-13 yrs and their parents	Active video game or "exergame"	3 mo	Not specified	Not specified	Unable to determine
Shapiro, et al. 2010[33]	Children, 6-11 yrs	Mobile applications/ mobile device	8 wks	Read SMS message	2 SMS sent per day	Unable to determine
Sirriyeh, et al. 2010[44]	Older adolescents, 16-19 yrs	Mobile applications/ mobile device	2 wks	Read SMS message	1 SMS sent per day	Unable to determine

Participant Characteristics
Four studies were gender-specific in recruitment and enrollment. [Table 1] Three of these studies enrolled only females,[28,34,42] and one study recruited only males.[40] The remaining eleven studies enrolled approximately equal numbers of males and females from racially/ethnically diverse backgrounds. Ages of participants across studies ranged from 6 to 19 years. Children (6-11 years) were the most frequently recruited age group (n=11 studies)[27,28,33-38,41,47,48] followed by young adolescents (12-15 years) (n=9 studies),[26,29,30,32,40,42,43,45,46] and older adolescents (16-19 years, n=2 studies). [31,44]

Intervention Duration and Session Frequency, Duration (Intervention "Dose")
Duration of intervention programs ranged from 2 weeks to 16 weeks. [Table 1] Within these time frames, frequency of intervention sessions were daily,[33,44] 1-2 times weekly,[28,32,34,38,40,42,46-48] and biweekly to monthly.[29,31,45] Three studies reported the intervention duration and frequency as the total number of hours spent on intervention activities (e.g. "5 hours") rather than as an activity occurring within a specific time frame.[26,30,37] Several studies allowed degree of participation to be entirely decided by the study participants rather than the investigators.[27,35,36,41,43] Total intervention dose (intervention session duration x frequency) estimated for reported intervention characteristics ranged from 1½ to 12 hours. Dose was not associated with a specific technology type, program focus (nutrition versus physical activity), or age group and could not be determined for thirteen out of twenty-two studies either because the intervention delivery was not assessed in this manner or was not reported in the publication. [Table 1]

Outcomes
Twelve out of twenty-two studies reported significant effects on nutrition[35,39,47] and/or physical activity behaviors.[31,32,34,38,42-46] [Table 2] In six of these twelve studies, there were significant differences between pre- and post-nutrition and/or physical activity behavior in the intervention versus the control groups.[31,32,34,38,46,48] In another study,[42] behavior change was observed in the comparison group (which received print materials) and not in the group which participated in the identical intervention delivered through the web. Whittenmore compared two levels of intervention intensity and demonstrated significant effects on diet (increased fruit, juice, vegetable intake, decreased sugar-sweetened beverages) and physical activity (increased moderate-to-vigorous physical activity) on both groups.[45] Sirriyeh et al and Ezendam et al both reported significant effects on physical activity behavior for all groups, regardless of intervention condition.[44,47] Long and colleagues reported significant effects on a behavioral mediator (nutrition self-efficacy) but not behavior,[30] while Baranowski et al influenced children's fruit and vegetable consumption but not water consumption, physical activity, or weight.[35]

The remaining ten studies[26,27,29,30,33,36,37,40,41,48] failed to find significant changes in the targeted behavior(s).

Four studies conducted follow-up assessments at six months [31,40,41,45] and one study at one year[31] after the conclusion of the intervention. Two of these studies continued to demonstrate no impact on physical activity at the six-month follow-up,[40,41] while one study by Whittenmore et al reported a sustained effect for nutrition and physical activity behavior changes at six months.[45] Another study by Mauriello et al reported a sustained effect for fruit/vegetable consumption but not for physical activity or screen time at six and twelve months.[31]

Change in physical activity and nutrition behavior by method of delivery
The magnitude of changes for each of the programs that achieved significant behavioral change is summarized in Table 2. One study in which participants in the face-to-face comparison arm of a web-based study reported a significant within-group difference in pre-post physical activity (PA) levels which was not reported in the web-based study arm.[42] In another study, girls in an eight week web-based program reported a significant increase in fruit, juice, and vegetable consumption post-intervention (1.01 serving increase; effect size of 0.13), as well as a significant increase in "physical activity yesterday" [2.62 baseline PA points (±1.36) to 4.05 (± 1.83), $p < .001$, an effect size of 0.32] and "physical activity, usually" from 3.74 (±1.75) points at baseline to 4.51(+ 1.98) at post-assessment ($p = .001$) and an effect size of 0.13.[34] Participants in a web-based video intervention who completed more than half of the intervention

Table 2
Study Outcomes by Technology Type

	STUDY OUTCOME		
TECHNOLOGY TYPE	**Significant Behavior Change**		**Not Significant**
Web-based application or computer-tailored program (n=13)	I vs C (tech vs print materials): Self-report PA↑, print group only (t[159]=3.21,p =.002)	[b]Marks, et al. 2006[42]	[c]Baranowski, et al. 2003b[28]
	I vs C: ↑22 min MVPA (vs ↓46 min MVPA); ↓ % diet fat from 30.7% to 29.9% (vs no change)	[c]Frenn, et al. 2005[32]	[c]Frenn et al., 2003[29]
	Pre-/Post: ↑FJV by 1.01 svgs (effect size 0.13); ↑ "PA yesterday" from 2.62 points (±1.36) to 4.05 (± 1.83); ↑usual PA from 3.74 points (±1.75) to 4.51 points (+1.98)	[c]Thompson, et al., 2008[34]	[b]Jago, et al. 2005[40]
	Pre-/Post for I1 and I2: ↑self-efficacy (p< .001), ↑FJV (p<.001), ↑MVPA (p<.001); ↓SSB (p<.001), ↓junk food intake (p<.01), ↓sedentary behavior (p<.001)	[c]Whittenmore, et al., 2012[45]	[a]Long, et al. 2004[30]
	I vs C: ↑PA (effect size= 12.46, p=.01), ↑FV intake (effect size= .14, p=.001), ↑PA knowledge (effect size= .16, p=.01), ↑nutrition knowledge (effect size= .18, p= 001); ↓waist-to-hip ratio (effect size=-.01, p=.02); ↓DBP (effect size =-1.12, p=.02)	[c]Chen, et al., 2011[46]	[a]Long, et al. 2006[26]
	I vs C: ↑MVPA (1 min/d for every I mo); no effect on FV intake; ↑daily steps, (at 10 Months, I took 1631 steps more/d than C)	[c]Gorely, et al., 2009[38]	
	I vs C: ↓odds (0.54) of drinking > 400mL/d SSB), ↓ consumption snacks (ß=-0.81snacks/d), ↑V intake (ß =19.3grams/d); ↓step count (ß=-10856 steps/wk); no effect on WW bread consumption, BMI, waist circumference, %overwt/obese, or sedentary behavior	[c]Ezendam, et al., 2011[47]	
	I vs C: ↑d ≥60 min PA (3.38 vs 2.72) at 2 mo; ↑ svgs FV (3.86 vs 3.0) at 2 mo, at 6 mo (3.55 vs 2.73), at 12 mo (3.67 vs 2.97)	[c]Mauriello, et al. 2010[31]	
Health behavior change video game (n=3)	Pre-/Post: ↑FJV by 1.0 svgs/d	[a]Baranowski, et al. 2003a[48]	[b]Goran, et al. 200537
	I vs C: ↑FV by 0.67 svgs/d (p<0.02); no effect on water consumption, MVPA, or weight	[c]Baranowski, et al., 2011[35]	
Mobile applications/mobile device (n=2)	I vs C: ↑ PA in all groups, including C	[b]Sirriyeh, et al. 2010[44]	[c]Shapiro, et al. 2010[33]
Active video game or "exergame" (n=4)	I vs C: ↑ PA at 6 wks (194 counts/min, p = 0.04) and at 12 wks (= 48 counts/min, p = 0.06)	[b]Mhurchu, et al. 2008[43]	[b]Maloney, et al., 2008[41]
			[b]Baranowski, et al. 2012[36]
			[b]Owens, et al., 2011[27]
TOTAL: n=22	**n=12**		**n=10**

Behavior change target: [a]nutrition only; [b]physical activity only; [c]nutrition and physical activity
Abbreviations: NS = non significant; PA = physical activity; FJV = fruit, juice, vegetable; FV = fruit, vegetable; SSB = sugar-sweetened beverage; DBP = diastolic blood pressure; WW = whole wheat; I = intervention; C = control; I1 = Intervention 1; I2 = Intervention 2; svgs = servings; mo = months; wks = weeks; d = days; min = minutes

sessions increased moderate-to-vigorous physical activity (MVPA) by an average of 22 minutes across the three day assessment period compared to the control group who decreased MVPA by average 46 minutes; this same intervention group also significantly decreased dietary fat intake (from 30.7% to 29.9%).[32] Participants in a 5-week (10-session) multi-media intervention reported a 1.0 serving increase in fruits, vegetables and juice compared to the control group who received no intervention;[48] a similarly designed study with a different game and higher dose increased fruit and vegetable consumption in children by 0.67 servings/day.[35] Participants enrolled in two different levels of intervention intensity increased fruit/vegetable consumption by 0.5 servings/day and moderate-to-vigorous physical activity from 3.4 (2.4) days/week to 4.1 (2.1) days/week.[45] Chen et al elicited significant effects on child physical activity (effect size, 12.46) and modest effects on vegetable and fruit intake (0.14) in participants of their web-based intervention.[46] Participants in a three-session computer-based program also reported eating significantly more servings of fruit, juice, and vegetables than the control group (3.38 versus 2.72 servings/day) and a

greater number of days doing at least 60 minutes of physical activity (3.38 compared to 2.72 days per week).[31] A 12-week active video game intervention significantly increased physical activity at six weeks compared to the control group (mean difference between groups was 194 counts/min measured by accelerometer), but these differences were not maintained at 12 weeks.[43] Gorely and colleagues demonstrated significant gains in participant MVPA (10 minutes more per day of MVPA compared to control) at 10 months.[38] Sirriyeh[44] tested a two-week SMS intervention designed to increase physical activity, and found an increase of 31.5 minutes of moderate activity per week across all four study conditions, including three intervention groups and the control group.[44] While Ezendam et al reported statistically significant improvements in vegetable intake (19.3g/day), this amounted to one-seventh of a serving.[47]

Process Evaluation

Process evaluation data were reported in thirteen of the twenty-two studies.[26,28-30,32-34,40-42,45,46,48] These data were used by investigators to evaluate fidelity to the intervention, e.g. the use of website and computer log-on data as a confirmation of content delivery to participants[28,34,40] or participant focus group, survey, or diary data to determine acceptability of the intervention approach.[26,30,32-35,38,41,42,48] Baranowski et al reported overall log-on rates to the GEMS study website (48% of expected rate for girls, 47% of expected for parents).[28] Jago et al., and Thompson et al., both reported 75% of expected average weekly log-on rates for participants in their web-based interventions,[34,40] and Chen reported 72% log-on for both intervention and control.[46] Whittenmore reported more than half of participants completed all lessons (53% in intervention 1, 70% in intervention 2).[45] Long and colleagues did not present log-on rates for either of their web-based nutrition interventions but did report that participants returned to website links that offered "game-like approaches" to learning during the intervention.[26,30] It was unclear whether participants actually clicked on links and engaged in intervention-related activities or just visited the website. These investigators also recorded behaviors, statements, comments, and requests from participants and used these data to evaluate satisfaction with intervention activities, concluding that participants experienced a high level of enjoyment during study activities and that a game-like format was desirable.[30] Gorely and colleagues interviewed teachers, but not students, to determine their views about the intervention;[38] teachers collectively agreed that strong support by a school administrator was critical to intervention success in a school.

Eighty percent of participants interviewed as part of a web-based physical activity intervention reported seeking additional information about physical activity as the result of the intervention.[42] Children and parents who participated in an SMS-mobile phone intervention designed to improve children's health behavior reported in a survey that they were more likely to participate in a similar program again when compared to participants in the paper/pencil and no-monitoring control conditions.[33] Maloney et al conducted focus groups and administered satisfaction surveys to youth participating in an active video gaming intervention. They reported 95% of youth endorsed the intervention delivery method, and more than half (54%) of parents believed that the active video game system increased their child's physical activity, despite intervention results demonstrating no effect on youth physical activity.[41] Similar surveys and interviews with children and parents post-gaming intervention revealed that most children (80%–90%) enjoyed playing both Diab and Nano.[35]

DISCUSSION

This review summarized the evidence for the use of web-based, computer game, video game, and mobile phone technologies to promote nutrition and physical activity behavior change in youth, ages 6 to 19 years. The twenty-two interventions that met inclusion criteria used varied technology types, study designs, and assessment methods which limited the conclusions that can be drawn regarding the efficacy of technology-based intervention strategies to change nutrition and physical activity behavior in youth populations. Web-based applications and computer tailored programs were the most frequently reported types of technology used in interventions; however, it was unclear whether these types were chosen because they were believed to be the most effective methods of engaging youth

and changing behavior or because they were readily available and accessible to participants and the research team. Intervention dose was not consistently reported, and there was often not enough information to determine exactly how much content participants were exposed to and interacted with during each program. The intervention phase of all studies was of relatively short duration (16 weeks or less), and intervention dose and delivery appeared to be guided in part by what was feasible given location and resource constraints, rather than by any evidence-based guidelines for behavior change. Further, due to the lack of comparison between technology-based and non-technology based interventions, an assessment of the feasibility and cost of technology and human involvement compared to traditional (face-to-face) approaches was not possible.

While twelve of the twenty-two studies reported statistically significant changes in behavior, these data were often not described in terms of practical significance (that is, it was unclear whether the behavior changed in a way that was related to health or disease prevention, with the exception of Thompson et al and Chen et al., who calculated effect sizes for nutrition and physical activity outcomes.[34,46] Only six studies discussed findings within the context of health behavior guidelines[27,29,35,38,48] or disease prevention.[44]

Although limited data do not allow for direct comparisons between traditional intervention approaches (i.e. delivered face-to-face) and technology-based approaches, the magnitude of behavior change reported by studies in this review were comparable to previous, face-to-face studies with similar intervention goals and populations.[49,50] This suggests that technology-based interventions are at least as effective as more traditional approaches in promoting nutrition and physical activity behavior change.

The use of technology has been suggested as an acceptable method of engaging youth in prevention activities,[51] and short-term behavioral outcomes have been observed. However, in the studies included in this review, process evaluation data were not consistently reported, and when included, did not provide a comprehensive picture of acceptability and feasibility of mHealth and eHealth approaches in youth. Since increased interactivity (between participants and content, or between participants and researchers) has been suggested as a potential way to increase engagement and improve behavioral outcomes of participants in e-Health interventions,[24] it is important to understand how much and what type of interactivity is needed to change behavior. Additional considerations include the preferred frequency and duration of information delivery, preferred topics, format or style, and the desired origin of information (e.g. health professional, leader, peer, etc.).

In summary, a variety of technologies are currently used by youth in everyday life, presenting health professionals and researchers with opportunities to reach youth in real time, and to provide them with the knowledge and motivation to engage in positive health behavior change. There are indications that youth access to and use of mobile technologies will continue to increase,[51] making it even more important to explore, identify, and systematically test approaches designed specifically for this population to determine the most effective and acceptable approaches.

Based on this review, we conclude there is insufficient systematic research on the use of technology to draw meaningful conclusions about promoting nutrition and physical activity behavior change in youth. Further, there has been no systematic approach to understanding intervention dose – the amount of interaction with interventionists and intervention content that will result in a significant behavior change – and poor fidelity has been reported across different program types (nutrition versus PA), technology types, and youth age groups, further hampering researchers' ability to assess acceptability and feasibility of mHealth and eHealth interventions. Determining the optimal degree of interactivity between youth, the content, and the interventionists is a crucial next step in moving this field of research forward. In part, optimal dose can be informed by youth themselves, using a youth-participatory approach to intervention design and implementation.[52] With the appropriate guidance, youth make excellent research team contributors, and their input is essential in informing the design of relevant, effective, and sustainable technology-based interventions.

Future research should formally evaluate the relationship between intervention dose, technology type (or delivery method), and youth behavior change. Continuing challenges with technology-based interventions include identifying scalable and cost-effective methods to deliver and maintain participant engagement with content in order to create meaningful and sustainable changes in nutrition and physical activity behaviors, to promote healthy lifestyle changes, and to prevent obesity in this at-risk population.

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