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# School Based Technology Interventions and the Impact on Dietary Behaviors Among Elementary-Aged Children: A Systematic Review

Review Article

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## Abstract

Childhood obesity has been on the rise since the 1980s, the same year the personal computer (PC) was introduced into society. During this time, children's dietary habits changed to consuming more high fat, high sodium foods and less nutritious (fruits, vegetables) foods. Additionally, children began using more technological devices to play games and watch videos.Technology, though, will not disappear anytime soon. Therefore, instead of restricting technology, researchers turn to technology to educate children about consuming more nutritious (fruits, vegetables) foods and less high fat, high sodium foods. This systematic review sought to identify and evaluate the effectiveness of school based technology interventions and the impact on improving dietary behaviors among children aged 6-12 years old. The findings revealed seven articles that increased fruit and vegetable consumption and decreased consumption of excess sugar among children. These particular studies included nutrition education, learning theories, and video games, text messaging or an app to engage children. Results showed regardless of the technology to educate children, these school-based technology interventions improved dietary behaviors among children. Therefore, incorporation of nutrition education and learning theories when designing these technological tools will engage and motivate a child to consume more nutritious foods.

**Keywords:** School Based Interventions; Dietary Behaviors; Applications; Video Games; Children.

## Introduction

### Childhood obesity within the United States

Childhood obesity has been steadily on the rise since the 1980s. In 1980, 7% of 6-12-year-old children were considered obese in the United States. In 2012, the obesity rate climbed to 18% among children of the same age and has remained stagnant for the past two years [1, 2]. Obesity is not just an issue within the United States, but globally. Global obesity rates have risen to 30% of the world's population, accounting for 2.1 billon individuals from 188 countries [3]. If the global obesity epidemic continues unabated, by 2020, nearly 60 million children will be considered overweight or obese [4]. The risks associated with obese children include a number of health complications and chronic diseases such as type II diabetes and cardiovascular disease [14, 5]. Many factors may contribute to the rise of obesity such as socioeconomic status and parenteral behaviors [6]. However, other behaviors such as decreasing consumption of fruits and vegetables and increasing consumption of high sodium and high fat foods may also contribute to this rise in obesity [7, 8]. Therefore, establishing effective interventions to improve dietary behaviors among children aged 6-12 years old is essential to reduce childhood obesity.

In 1980, the personal computer (PC) was created, sparking the technology boom of the new millennium. In the era of the technology boom, children are constantly plugged in spending 7.5 hours each day on entertainment media [1, 9-10]. Innovations in technology have drastically impacted the function of products making technology ownership at a younger age socially acceptable. Cell phones previously had one function -- to make a telephone call. Now, though, cell phones capture children's attentions

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by allowing them to play games, listen to music, and watch videos. In 2009, one-third of children aged 8-10 years old reported ownership of a cellphone, video games, iPads and laptops [10]. Thus, one method of educating children on reducing obesity-related behaviors (e.g. dietary behaviors) may be through technology in the classroom. However, children have low interests in learning about nutrition, presenting a challenge of implementing effective technological interventions to promote positive behavior changes (e.g. increased consumption of fruits and vegetables) [11].

Dietary behaviors of children are influenced by the school environment including peer influence, school meals and nutrition education programs, as children spend an average of six hours per day in school [12]. Implementing technology into classrooms increases learning motivations and achievements in children, resulting in competency of specific subjects in comparison to conventional teaching methods such as lectures, worksheets and presentations [13-17]. Researchers have found game-based learning could be the best method to trigger children's learning motivation compared to traditional teaching methods [18-22]. Game-based learning attracts the child's attention through the anticipation of having fun and promoting abstract thinking [23-25]. The pace of learning can be controlled by the child, providing reinforcement and expansion of material through technology interventions. Multiple learning styles are embedded in school based technology interventions including visual, aural and physical to encourage success among all children [26-30]. Offering a school based technology intervention to encourage improvement on dietary behaviors (e.g. increased consumption of fruits and vegetables) may serve as an effective nutrition education program to combat childhood obesity. Engaging children in technology in which they find enjoyable, while simultaneously providing nutrition education provides an opportunity to promote positive dietary behaviors (e.g. increased consumption of fruits and vegetables). The purpose of this investigation is to identify and evaluate the effectiveness of school based technology interventions and the impact on the dietary behaviors among children aged 6-12 years old.

## Materials and methods

### Systematic search

A systematic review search was conducted within CINAHL, PubMed and ERIC databases. The search *terms technology/active learning, fruit/vegetable consumption, dietary behavior, applications, video games, children and school based interventions* were used within each database. Searches were limited to the English language between the years of 2010 and 2016.

### Screening

The selection of articles was conducted using three phases. The first phase represented the article search using CINAHL, PubMed and ERIC using the above keywords. In Phase two, duplicate articles were removed and one researcher screened the title and abstracts of articles using a 7-point inclusion and exclusion criteria created by the researcher to evaluate the articles. The following criteria was created: (1) published peer-reviewed studies; (2) published between 2010 to 2016; (3) experimental studies; (4) study participants involved children 6 to 12 years of age; (5) technology based interventions conducted in school; (6) technology included video games, text messaging or apps; and (7) outcome measure included healthy dietary behaviors. In the final phase, two researchers independently evaluated the full text of articles using the established 7-point inclusion and exclusion criteria.

### Data extraction

The researcher organized and designed a table (Table 1) to compare data extracted from each peer-reviewed article included. Data extracted included authors, date of publication, intervention name, target population, design/intervention groups, technology application, duration of study, intervention modalities for treatment group, evaluation measures and technology intervention effects.

### Critical appraisal of material

The methodological quality of each study was assessed using the Quality Criteria Checklist: Primary Research of the Academy of Nutrition and Dietetics [31]. The Quality Criteria Checklist addresses ten specific validity questions including: (1) research question statement; (2) selection bias;(3) group comparability; (4) handling of withdrawals; (5) blinding use; (6) intervention regiment or exposure factors; (7) outcomes definition and measurements; (8) statistical analyses; (9) conclusions; and (10) potential funding bias. Each validity question was assessed using three different categories including yes, no and unclear (Table 2).

## Results

### Included studies

A total of 56 articles were identified through CINAHL, PubMed and ERIC database. Following the 7-point inclusion and exclusion criteria, 7 articles remained (Figure 1).

### Appraisal

The included studies incorporated various nutrition education technology including video games (n=4), text messaging (n=2) and apps (n=1) (Table 1). Following independent quality appraisal, the validity scores assigned for each paper were revised by both researchers. There was high agreement between researchers regarding the validity of the scores for the 7 studies. Table 2 summarizes the internal validity of the 7 studies. The mean quality score was 8.7. Studies receiving the lowest ratings based on validity were due to omitting inclusion/exclusion criteria critical to the study (n=4), missing health demographics and other characteristics of subject description (n=2), non-comparable study groups (n=3), unequal distribution of factors across the study groups at baseline (n=4), short period of follow up for important outcomes to occur (n=3) and missing sources of funding and affiliations described (n=3).

### Study range and characteristics

The seven studies included 3,578 participants with a mean of 511 participants ranging from 66 to 2,477 participants within the studies. Participants of studies were children ranging from 8 to 12 years of age. 6 studies were randomized controlled studies [32-37] and 1 study was a quasi-experimental nonequivalent control study

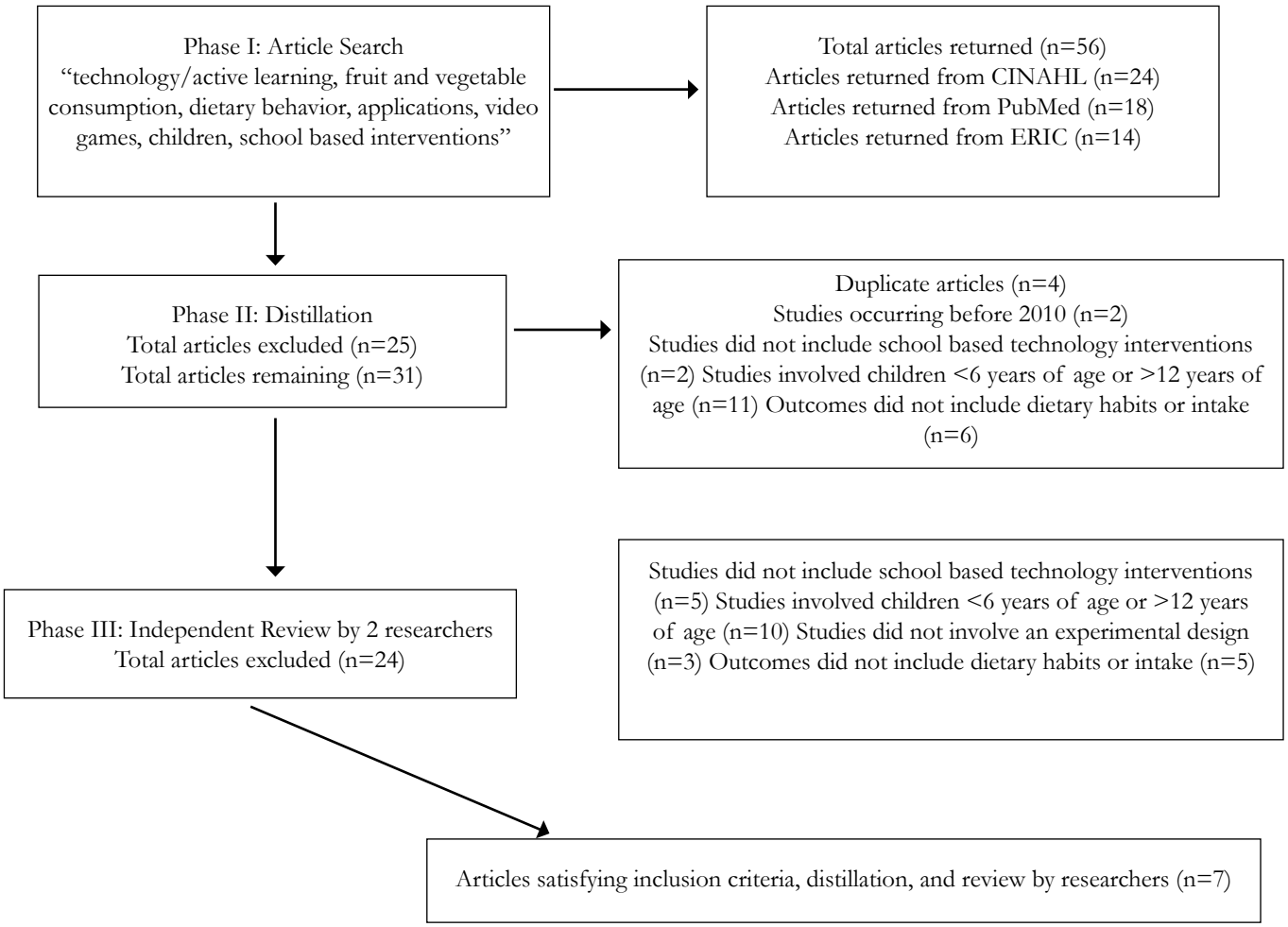
**Table 1. Summary of Seven Studies Included in Systematic Review**

| Authors (Year) | Location | Design/ Duration | Population/ Intervention Groups | Technology Intervention | Intervention Modalities for Treatment Group | Evaluation Measures | Technology Intervention Effects |
|---|---|---|---|---|---|---|---|
| Thompson et al., -2015 | USA | Four-group *RCT 12 weeks | 9-11 year olds Sample: n=400 Control: n=97 Action: n=98 Coping: n=95 Both: n=97 | Video game | 24-hour diet recall Goal setting Nutrition education | **FV intake | Increased FV intake in action group by 50% No significant change in other groups |
| Baranowski et al., -2011 | USA | Two-group RCT 4 weeks | 10-12 year olds Intervention: n=103 Control: n= 50 | Video game | 24-hour diet recall Goal setting Nutrition education | FV intake Water consumption | Increased FV intake to .67 servings per day No significant change in water consumption |
| Sharma et al., -2015 | USA | RCT 6 weeks | 9-11 year olds Intervention: n=44 Control: n=50 | Video game | 24-hour diet recall Portion estimation Nutrition education | FV intake Sugar intake | No significant difference in FV intake Decreased sugar intake (-4.9/1,000 kcal) |
| Yien et al., (2011) | Taiwan | Quasi-experimental nonequivalent- control group 4 weeks | 8-9 year olds Intervention: n=33 Control: n=33 | Video game | Nutrition education Computer-based learning | Food & Drink habits Nutrition Knowledge Nutrition Attitudes | Enhanced food and drink (+2 on post-test) Nutrition knowledge increased (+2.75 on post-test) No significant difference in nutrition attitudes |
| Silva et al., (2015) | Portugal | RCT 8 weeks | 8-10 year olds Intervention: n= 69 Control: n= 70 | Text messaging | Goal setting Tailored feedback messages Reported FV intake | FV intake | Increased FV intake to ~1 serving |
| Bech-Larson et al., (2013) | Denmark | RCT 4 weeks | 12 year olds Intervention: n=169 Control: n=87 | Text messaging | Nutrition education Tailored feedback messages Reported FV intake | FV intake | Increased FV intake to 0.7 servings |
| Struempler et al., (2014) | USA | Quasi-experimental 17 weeks | 8-9 year olds Intervention: n= 1,674 Control: n=87 | App | Interactive curriculum Weekly FV tastings Take home messages | FV intake | Increased fruit intake by 0.35 weekly servings Increased vegetable intake by 0.66 weekly servings |
| Note: *RCT = Randomized Control Trail; **FV= Fruits and Vegetables | | | | | | | |

**Table 2: Summary of Validation Scores based on Systematic Review Articles (n=7)**

| Author, Year | Validation Score | Selection of study participants clear of bias | Inclusion/ exclusion criteria | Characteristics of subjects described | Study groups comparable | Description of assigning groups | Similarity among groups | Description of method to handle withdrawals | Withdrawals described | Co-interventions described | Follow up for results sufficient |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Thompson et al.,2015 | 9.4 | Yes | Yes | Yes | No | Yes | No | Yes | Yes | No | Yes |
| Baranowski et al., 2015 | 9.1 | Unclear | No | Yes | Yes | Yes | Yes | No | Yes | No | No |
| Sharma et al.,2015 | 8.7 | No | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |
| Yien et al.,2011 | 8 | Unclear | No | No | Yes | No | No | No | Yes | No | No |
| Silva et al.,2015 | 8.8 | Unclear | No | Yes | Yes | Yes | Yes | No | No | No | Yes |
| Bech-Larsen et al.,2013 | 7.8 | Unclear | No | No | No | No | No | No | Yes | No | No |
| Struempler et al.,2014 | 9.3 | Yes | Yes | Yes | No | No | Yes | No | Yes | Yes | Yes |

**Figure 1. Diagram illustrating selection of articles for systematic review**




[22]. 4 studies were conducted in North America [32, 34, 36-37], 1 in Taiwan [22], 1 in Denmark [33] and 1 in Portugal [35]. The duration of interventions lasted from 4 to 17 weeks.

### Synthesis of results

Of the 7 studies, 4 studies focused on video games [22, 32, 34, 37]. The results showed that children increased fruit and vegetable consumption on average by 20% and decreased sugar consumption on average by 10% [22, 32, 34, 27]. 2 studies focused on text-messaging [33, 35]. Results from these studies demonstrated children increased fruit and vegetable consumption by approximately 27% [33, 35]. The 1 study that used an app, children increased fruit and vegetable consumption by 0.35 weekly servings and 0.66 weekly servings [36].

Of the 7 studies, 2 studies incorporated different elements within their school based technology interventions including fruit and vegetable tastings, weekly take-home activities, traditional education lessons, and emphasis of fruit and vegetables at every class [36] and 2, 45-minute educational visits from a dietitian twice within 15 weeks [33]. Each intervention was developed using specific theories to promote behavior change within children. 4 studies used the social cognitive theory [22, 32, 34-35], 2 used the goal setting theory [33, 37] and 1 used the experiential learning theory [36].

## Discussion

The purpose of the systematic review was to identify and evaluate the effectiveness school based technology interventions has on impacting dietary behaviors among children aged 6-12 years old. The findings from this review indicated that school based technology interventions may be effective in improving children's dietary behaviors toward increasing their consumption of fruits and vegetables.

## Design of the nutrition education technology

1 study used the iPad app, Body Quest (BQ): Food the Warrior to improve dietary behaviors among children [36]. Developers based the BQ app curriculum on Kolb's Experiential Learning Theory [36]. Kolb's Experiential Learning Theory involved a learning cycle that includes 4 stages: (1) concrete experiences; (2) reflective observations; (3) abstract conceptualization; and (4) active experimentation [38]. Borun and colleagues [39] examined the relationship between Kolb's four stages of learning and preference for learning activities among children to help create effective multimedia curriculums. Results indicated children preferred activities emphasizing abstract conceptualization and concrete experiences [39]. They concluded, when incorporating experiential learning theory into multimedia curriculum, design and role-playing activities that include simulations or puzzles should be implemented

as a means to increase activity appeal [39]. Therefore, researchers designed the BQ app, that incorporated simulations for children to learn about food groups and apply that knowledge to create a meal plan for themselves. However, improvement in dietary behaviors among the children may have been attributed to other aspects of the BQ curriculum such as weekly fruit and vegetable tastings, playing the BQ card deck game or weekly reinforcement through take-home activities and messages [36].

Bandura's social cognitive theory was implemented within the 4 video game interventions and the 1 text messaging intervention [22, 32, 35, 37]. Bandura's social cognitive theory emphasizes observational modeling, outcome expectations, goal setting and self-regulation [40]. Observational modeling helps shape behaviors of children by the demonstration of specific behaviors. Within the video games, creators used avatars to display observational learning. Avatars displayed positive dietary behaviors as they consumed fruit and vegetables. Additionally, children designed these avatars, thus the avatars resembled them as a means to encourage positive dietary behaviors by observational learning [34, 40]. In one of the video games, Quest to Lava Mountain (QTLM), the researchers observed that children had positive dietary behaviors towards fruits and vegetables. They concluded children modeled the behavior of their avatars because as the avatars consumed more fruits and vegetables they became stronger and overcame obstacles [34].

Bandura's self-regulation component was incorporated into the video games by engaging the children. As a result, children were more motivated to consume more fruits and vegetables outside of the game. Children were able to control the pace of learning and completed difficult levels [34]. Throughout the games, children were subjected to knowledge checks through quizzes and goal setting activities as a means to improve their dietary behaviors [32, 34, 37]. The social cognitive theory represents behavior change that is learned through modeling, which is incorporated within the video games [32]. Prior studies [41, 42] had similar results when using the social cognitive theory to improve dietary behaviors among children. When outcome expectations were associated with positive outcomes (e.g. achieving a level), children were more likely to change their dietary behaviors [41, 43].

Regardless of the theories used to design the video games, children who received nutrition education, on average 90 minutes per week within the classroom, demonstrated an increased consumption of fruits and vegetables [22, 32, 37] or decreased their consumption of excess sugar [34]. The various learning theories used within the video gamesimproved dietary behaviors among children due to they were engaged and motivated [17-18, 22, 44-46].

The 2 text-messaging studies developed their interventions using the goal setting theory and self-monitoring to improve dietary behaviors among children [32-35]. Self-monitoring, immediate feedback, and specific goals are elements within behavioral theories to encourage a positive change in a particular behavior [35]. In each of the study designs, researchers used text messaging to help children create specific goals to improve their dietary behaviors. Specific goals created by children promoted behavior change as these goals were actionable and, if not attainable, there was a coping plan in place [37]. Action plans specify exactly how the goal will be attained (e.g. what, when, where) to enhance goal attainment [37]. Coping plans allow children to use problem solving skills to overcome barriers that may prevent them from reaching their specific goal using an "if/then" approach [37]. When children create their own specific goals, goals are realistic to their lives, motivate them for continued participation, and once achieved, allow them to push themselves and create new goals to conquer other challenges [35]. In these text-based studies, children reported via text message their progress and then received tailored feedback messages based on their performances (e.g. 'Great, you met your goal for physical activity and screen time! What happened to fruits and vegetables? ') [33, 35].

Tailored feedback messages of support were necessary for children to remain motivated at all levels – those who were meeting their goals, lagging in reaching their goals, or who were at risk for abandoning their goals [33, 35]. Results indicated that the implementation of goals within a text messaging system motivated children to continue participating in these nutrition education programs [33]. Additionally, results showed children who texted self-monitored their goals as they were able to reflect, problem-solve, and develop new ways to improve their dietary behaviors [33, 35]. Overall, motivating and engaging children through self-monitoring and goal-setting in a technology environment may help them improve their dietary habits.

## Strengths and limitations

The focus of this review was on school-based technology interventions to improve children's dietary behaviors, thus limited articles were identified. Considering factors such as physical inactivity and parental behaviors may modulate a child's risk for obesity, further research should target nutrition education technology that children may use in the household or at least incorporate parents during these learning activities.

The quality of the review is dependent on the quality of the studies. From the 7 studies that met the inclusion criteria, 4 studies were video games, 2 were text-based messaging and 1 was with an app, in which each of the interventions ranged from 4-17 weeks. Even though results were positive in which children increased their intake of fruits and vegetables or decreased their consumption of excess sugar, changing dietary behaviors in a short-period of time is difficult to sustain especially if children are dependent on parents, the school, and the community itself. Therefore, time and resources need to be expended on creating effective tools to sustain a child's dietary behavior.

A core strength of this systematic review is the incorporation of various technological methods that were designed based on learning theories to teach children about improving dietary behaviors.

## Recommendations

The following recommendations for policy and practice can be drawn from the review of current literature:

1. Engaging and motivating children to learn about nutrition seems to improve their dietary behaviors.
2. Identifying and evaluating elements that are effective in increasing children's knowledge and behaviors towards eating a more nutritious diet is important to reduce obesity.

Considering there is a lack of evidence to show quality nutrition education technology programs enhance and sustains children's dietary behaviors to reduce obesity; future research is needed. A focus should be on evaluating school based technology interventions and thelong term effects these interventions has on children's dietary behaviors to reduce obesity.

## Conclusion

While the rate of childhood obesity is stabilized, effective interventions are needed to promote healthy dietary habits among children to combat childhood obesity. While technology continues to engulf the lives of children, technology based interventions to promote healthy dietary habits in the schools should be considered. Evidence from this review suggests that technology can be used to improve a child's dietary behavior. For individuals who may decide to implement technology based interventions to promote healthy dietary habits into practice, quality of interventions need to be assessed. Dietary habits are initially shaped within families but interventions that can be implemented at home and school provides a stronger influence to improve children's dietary behaviors to reduce obesity.

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