iPhone App Adherence to Expert-Recommended Guidelines for Pediatric Obesity Prevention

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Abstract

Background: Pediatric obesity is a serious and prevalent problem. Smartphone technology, which is becoming increasingly available to children of diverse backgrounds, presents a unique opportunity to instill healthy behaviors before the onset of obesity. Past studies have examined the use of smartphone applications as tools of health behavior modification for adults. The present study examines the content of children's exercise and nutrition smartphone apps.

Method: Sixty-two iPhone apps were identified and coded by two independent raters for adherence to expert-recommended behaviors (e.g., five fruits/vegetables per day) and strategies (e.g., self-monitoring diet/physical activity) for the prevention of pediatric obesity.

Results: App behavioral and strategy index scores were uniformly low. Apps were more likely to address expert-recommended behaviors for the prevention of pediatric obesity (93.5%), whereas few apps addressed recommended strategies (20.9%). The most common behaviors addressed included physical activity (53.2%) and fruit/vegetable consumption (48.3%). Other important behaviors (e.g., screen time [1.6%] and family meals together [1.6%]) were rarely addressed.

Conclusions: Current children's diet and exercise apps could be improved with increased adherence to expert-recommended guidelines, especially expert-recommended strategies.

Introduction

Pediatric obesity is an area of special concern not only because of the high rate of obesity among children, which has almost tripled in the last three decades,¹ but also because of the unique window of opportunity that childhood provides for establishing long-term health. To date, however, interventions to prevent obesity have had mixed success. A review of obesity prevention interventions for girls found that even the most intensive interventions had limited long-term success.² Whereas intensive, in-person interventions represent the majority of current obesity prevention approaches, they are not only costly and difficult to maintain past the treatment phase, but also are limited in their reach and large-scale disseminability.³ In recent years, researchers have given increasing attention to technology-based interventions as a means of pediatric obesity treatment and prevention. A recent review article identified 24 studies that used electronic media alone

or as an adjunct intervention for the prevention and treatment of pediatric obesity.⁴ Results from these studies were mixed, with only three finding a significant reduction in BMI in the electronic intervention group, relative to the comparison group,^{5–7} and 10 reporting no clear impact of the electronic interventions on diet and/or physical activity outcomes.^{5,6,8–15} Notably, nearly all of the studies used the Internet or a CD-ROM, with only one utilizing mobile technologies.¹⁶

Smartphones are mobile phones capable of running software applications, commonly referred to as apps. Apps are already widely used in the healthcare industry, and many experts predict that this trend will continue to grow.^{17–19} With an estimated 20 million apps downloaded from iTunes in 2012 alone,²⁰ mobile technology interventions could have a substantial impact on population health. Children's widespread access to smartphone apps, their surprising ability to understand and manipulate apps from a young age,²¹ and the ability of apps to prompt

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self-monitoring, cues to action, and reinforcement of desired behaviors²² make smartphones a unique, but understudied, tool that could address pediatric obesity across age and demographic groups. Although most young children do not own smartphones, 46% of US youth have a cell phone by the age of 12, and the age at which youth receive their first cell phone is lowering each year.²³ More telling is the large percentage of children who use their parents' smartphones on a regular basis. As of 2012, 45% of US adults owned smartphones, with racial/ethnic minorities being equally as likely to own a smartphone as their Caucasian counterparts.²⁴ A recent study indicates that two thirds of parents allowed their young children (ages 4–7 years) to use their iPhones and iPads for children's apps.²¹ The same study also found that children can gain valuable knowledge from apps,²¹ demonstrating the ability of apps to facilitate learning, comprehension, and, possibly, behavior change, even in young children.

Several studies have examined smartphone applications for their ability to promote and modify health behaviors in adults. One study reviewed iPhone apps for their adherence to expert-recommended treatments for tobacco dependence, finding that few apps adhere to the established guidelines.²⁵ A separate study examined the content of iPhone weight loss apps for adults, again finding an overall lack of adherence to expert-recommended guidelines.²⁶ However, there are no known studies that have examined children's smartphone apps for obesity prevention content. Considering the distinct role that children's smartphone apps could play in lifelong healthy weight maintenance, the aim of this study was to assess the extent to which existing children's diet and exercise-related apps adhere to expert-recommended behavioral guidelines and strategies for pediatric obesity prevention.²⁷

Methods

App Search Procedure

The aim was to identify English-language, iPhone-compatible nutrition and physical activity apps for children. All iPhone applications can be found and downloaded on Apple Inc.'s digital media library and multi-media player, iTunes.²⁸ Using the iTunes search function, the phrases "kid's fitness," "kid's nutrition," and "kid's exercise" identified a total of 237 apps on September 6, 2012. Various other search terms, including "children's nutrition," "children's exercise," and "children's health," were tested, but did not yield additional results. Children's apps were not separated by specific target age group because iTunes does not specify age range for apps. The description of each app provided in iTunes was read by the first rater and assessed for relevance. Irrelevant apps ($n = 173$) were excluded from the study based on one of the following scenarios: (1) *Repeat Apps*. In the instance that the same app was produced by two or all three of the searches, the app was only included once. (2) *Unrelated Apps*. Apps that had nothing to do with children's

physical fitness or diet were excluded (*e.g.*, apps that were described as math practice, memory games, first-aid education, and science education). (3) *Adult Apps*. Apps designed *exclusively* for adults were excluded. However, apps designed to be used by parents to focus on the health of their children (*e.g.*, "teach your kids to exercise" or "healthy recipes your kids will love") were included in the current study. (4) *Non-English Language Apps*.

Based on the apps' description in iTunes, categories that encompassed the most common functions of the identified apps were developed by the first rater. These categories were later verified by the first and second raters when they downloaded and experienced each app. The first rater also obtained metrics concerning each app's price and user-derived star rating. Within iTunes, apps are scored on a scale from 1 to 5 stars, wherein 1 star is the lowest rating and 5 stars is the highest rating. iTunes then averages user ratings to produce an app's star rating.

In order to maximize the accuracy of coding, both raters downloaded the identified apps onto their smartphones and spent time exploring and experiencing each app. Coding required an average of approximately 30 minutes per app, per rater.

App Rating Criteria for Behavioral Index Scores

Two independent raters coded the apps for their adherence to American Academy of Pediatrics (AAP) guidelines for the prevention of pediatric obesity.²⁹ Both raters were public health graduate students with experience in pediatric obesity prevention. These AAP guidelines, which were derived from the 2007 Expert Committee recommendations for the prevention of childhood obesity, include a total of 12 behavior recommendations.^{29,27} However, infants and children under the age of 2 years were not within the scope of this study; therefore the breastfeeding recommendation was excluded. In addition, "Eat a diet rich in calcium" and "Switch to low-fat dairy products" were combined into a single recommendation, "Switch to low-fat dairy products as part of a diet rich in calcium." The final list of behavioral targets, for the prevention of obesity in children, used in this study is displayed in Table 1.

Based on criteria used in similar studies,^{25,26} raters independently gave each app a score from 0 to 3 for each of the 10 behaviors. A score of "0" indicated *no* recommendation for the behavior. A score of "1" indicated a *weak* recommendation for the behavior (*i.e.*, children were exposed to images of fruits and vegetables, but not explicitly encouraged to eat them). A score of "2" indicated a partial or *moderate* recommendation for the behavior (*i.e.*, the app recommended eating more fruits and vegetables, but did not recommend five servings per day, or the app prompted or encouraged children to exercise, but did not recommend 1 hour per day). A score of "3" indicated a full or *strong* recommendation of the behavior (*i.e.*, the app recommended eating five servings of fruits and vegetables per day or recommended getting 1 hour of physical activity per day). The scores for all behavior recommendations

Table 1. Expert-Recommended Behaviors and Strategies for the Prevention of Pediatric Obesity²⁷

Recommended behaviors
Eat five fruits and vegetables per day
Get 1 hour of physical activity per day
Limit screen time to less than 2 hours per day
Limit consumption of sugar-sweetened beverages
Eat breakfast daily
Switch to low-fat dairy products as part of a diet rich in calcium
Regularly eat family meals together
Limit fast food, take-out, and eating out
Prepare foods at home as a family
Eat a high-fiber diet
Recommended strategies
Goal setting: Children should set clear goals that reflect progress toward target behavior(s).
Positive reinforcement: Children should be encouraged for effort and achievements related to target behavior(s).
Self-monitoring: Children should be encouraged to record their relevant behaviors, efforts, and progress.
Cognitive restructuring: Negative cognitive patterns should be discouraged and successes, including partial successes, should be highlighted.

were then added, resulting in an index score representing overall adherence to expert-recommended behaviors. This *behavioral index score* has a range from 0 to 30; apps that strongly addressed all behavioral recommendations could receive a score of 30 and those that addressed none of the behavioral recommendations could receive a score of 0.

App Rating Criteria for Strategy Index Scores

Apps were also coded for their adherence to the Expert Committee's four recommended strategies for the prevention of childhood obesity (see Table 1).²⁷

Raters independently gave each app a score from 0 to 1 for each of the four recommended strategies. A score of "0" indicated that the app did not utilize the recommended strategy. A score of "1" indicated that the app utilized the recommended strategy. A dichotomous, as opposed to categorical, outcome was used for adherence to the recommended strategies because it was determined *a priori* that an app would either address the strategy or it would not, and there were no empirically based guidelines for "partial" or "moderate" adherence to the strategies (*e.g.*, self-monitoring). Scores were then added, resulting in a second index score representing overall adherence to the Expert Committee's recommended strategies. This *strategy index score* has a range from 0 to 4; apps that incorporated

all of the expert-recommended strategies could receive a score of 4, and apps that did not incorporate any of the expert-recommended strategies could receive a score of 0.

Results

App Coding

Of the 237 apps produced by the search terms, 173 were deemed irrelevant (154 were unrelated to nutrition and exercise, 12 were repeat apps, six were for adults only, and one was in a foreign language) and excluded. Sixty-four apps were downloaded; however, one was nonfunctional and could not be coded and one was a repeat app marketed under a different name. This resulted in 62 total apps that were included and coded for adherence to expert recommendations by two independent raters. There was 95.2% agreement between the two raters. Within the 4.8% of coding discrepancies, 58.3% differed by one point and 41.7% differed by two or more points. When there was a discrepancy, the raters reevaluated the app together and came to a consensus.

App Characteristics

Price. The average cost of the apps was \$1.09. Apps ranged in price from \$0.00 to \$9.99, although half (50%; 31) of the apps were free. The highest-scoring app (behavioral index score = 26; strategy index score = 3) cost \$3.99. Interestingly, the app with the highest price (\$9.99) had very low index scores (behavioral index score = 1; strategy index score = 0).

User-derived star rating. Star rating information for each app can be found in Table 2. iTunes user ratings were available for 50% of the apps at the time of data collection. Of those that had received ratings, the maximum rating was 5 stars, and the minimum was 2 stars, with an average of 3.6 of 5 stars. There was wide variability in the number of users who had contributed to the score (minimum, 5 raters; maximum, 9483 raters). Examination of the association between our objectively measured index scores and user ratings indicated a significant moderate, positive association ($r = 0.31$; $p = 0.043$), suggesting that apps with higher user satisfaction also had greater adherence to expert guidelines. These findings suggest a reasonable degree of consistency between user ratings/satisfaction and app adherence to expert guidelines.

Readability. Readability was assessed retrospectively. Of the 54 apps for children, 48 were available at the time of readability assessment. Of these 48 children's apps, 79.2% could be operated without reading—they had no written language, all the written language was also narrated, or they only had short written phrases, for example, "start game" or "play." Some (14.6%) were partially functional without reading, meaning, for example, that a young user could play a game featuring fruits and vegetables, but might not understand the written health tips at the end of each level. Some (6.2%) required reading, meaning that the app could not be experienced or understood without the

Table 2. Name, Behavioral, and Strategy Index Scores, Popularity, Price, Description, and Category for Each of the 62 Apps Included in the Study, Listed by Combined Behavioral and Strategy Index Scores in Descending Order

App name	Popularity (1–5 stars)	Price	Description
Iron Kids Behavioral index score: 26 Strategy index score: 3	Rating not available	\$3.99	Primarily designed to be a personal training aid; in addition, app links to external health education tools Categories: nutrition education, exercise demonstrations/instructions, and diet/exercise log
WakeMyMojo Behavioral index score: 16 Strategy index score: 2	4.5 stars 9 reviews	Free	Asks users to keep track of daily food intake, activity, and mood; gives health information Categories: nutrition education, exposure to fruits and vegetables, exercise education, diet/exercise log
Eat-And-Move-O-Matic Behavioral index score: 16 Strategy index score: 0	4.5 stars 14 reviews	Free	Gives calorie and nutrition information for common foods and information about calories burned during exercise Categories: nutrition education, exposure to fruits and vegetables, exercise education
Nutritious Family Meals & Recipes Behavioral index score: 12 Strategy index score: 0	Rating not available	Free	App to be used by parents; provides healthy recipes and nutrition tips Categories: nutrition education, meal planning
Awesome Eats Behavioral index score: 11 Strategy index score: 0	5 stars 123 reviews	Free	Video game featuring fruits, vegetables, and healthy foods that must be sorted into the correct piles; gives health and nutrition information and tips at the end of each level Categories: nutrition education, exposure to fruits and vegetables
A CAMP CARROT CHEER: For good nutrition Behavioral index score: 10 Strategy index score: 0	Rating not available	\$1.99	Rhyming book, explicitly encourages nutrition and exercise Categories: nutrition education, exposure to fruits and vegetables, exercise education, narrated book
Keep your Vitality! Okinawa Game Behavioral index score: 10 Strategy index score: 0	Rating not available	\$1.99	Video game with falling food that must be caught if healthy and avoided if unhealthy; provides health tips Categories: nutrition education, exposure to fruits and vegetables
Kids Food Adventure/Choose My Food Behavioral index score: 6 Strategy index score: 3	Rating not Available	\$0.99	Users are given virtual stickers for trying new healthy foods in real life. Encourages trying a wide range of new foods and gives detailed nutrition information Categories: nutrition education, exposure to fruits and vegetables, diet/exercise log
Free to Play Okinawa Game Behavioral index score: 8 Strategy index score: 0	3.5 stars 45 reviews	Free	Video game with falling food that must be caught if healthy and avoided if unhealthy; provides health tips Categories: nutrition education, exposure to fruits and vegetables
Food Master! Okinawa Game Behavioral index score: 8 Strategy index Score: 0	Rating not available	\$0.99	Video game with falling food that must be caught if healthy and avoided if unhealthy; provides health tips Categories: nutrition education, exposure to fruits and vegetables
LaLa Lunch Box Behavioral index score: 5 Strategy index score: 1	5 stars 34 reviews	\$1.99	Has user plan their lunch; suggests that each lunch include fruits, vegetables, and protein Categories: meal planning, exposure to fruits and vegetables, diet/exercise log
The NOK ROCKERS: Trouble in Slowville Behavioral index score: 5 Strategy index score: 0	Rating not available	Free	Video game where users collect healthy foods and avoid junk foods Categories: exposure to fruits and vegetables
Pocket Workout: Calisthenics Behavioral index score: 2 Strategy index score: 3	3 stars 50 reviews	\$4.99	Personal training system; assists in creating and implementing a workout routine Categories: exercise demonstrations/instructions, diet/exercise log
Pocket Pull-Up Behavioral index score: 2 Strategy index score: 3	2.5 stars 14 reviews	\$1.99	Personal training system; assists in creating and implementing a workout routine Categories: exercise demonstrations/instructions, diet/exercise log

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Table 2. Name, Behavioral, and Strategy Index Scores, Popularity, Price, Description, and Category for Each of the 62 Apps Included in the Study, Listed by Combined Behavioral and Strategy Index Scores in Descending Order *continued*

App name	Popularity (1–5 stars)	Price	Description
Pocket Crunch Behavioral index score: 2 Strategy index score: 3	3.5 stars 11 reviews	\$1.99	Personal training system; assists in creating and implementing a workout routine Categories: diet/exercise log
Pocket Push-Up Behavioral index score: 2 Strategy index score: 3	2 stars 7 reviews	\$1.99	Personal training system; assists in creating and implementing a workout routine Categories: exercise demonstrations/instructions, diet/exercise log
Healthy Recipes Behavioral index score: 5 Strategy index score: 0	Rating not available	Free	App to be used by parents; provides healthy recipes and nutrition tips Categories: nutrition education, meal planning
Set4Sport Behavioral index score: 2 Strategy index score: 3	Rating not available	\$0.99	App to be used by parents; videos and instruction on how to play with children and keep them active Categories: exercise demonstrations/instructions, exercise education
Lil' Shopper for iPhone Behavioral index score: 4 Strategy index score: 0	Rating not available	\$1.99	App allows users to play while being exposed to fruits and vegetables. Users drive a virtual car to the grocery store and pick out healthy foods on a virtual shopping trip. Junk foods are not allowed in the cart. Categories: meal planning, exposure to fruits and vegetables
GeoPalz Behavioral index score: 2 Strategy index score: 2	4.5 stars 5 reviews	Free	This pedometer app makes walking a game. The app has map and log features. Users are given points for number of steps they take and can compete with their friends. Categories: movement-powered app, diet/exercise log
yumPower Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	App to be used by parents; uses current location to find nearby restaurants and provides calorie information on menu items Categories: meal planning, nutrition education
Peekaboo Fridge Behavioral index score: 3 Strategy index score: 0	3.5 stars 20 reviews	\$1.99	App allows users to play while being exposed to fruits and vegetables. User taps cartoon images of fruits, vegetables, and healthy foods to hear the names pronounced and see the foods dance. Categories: exposure to fruits and vegetables
D.W.'s Unicorn Adventure Behavioral index score: 3 Strategy index score: 0	4.5 stars 15 reviews	\$0.99	Video game where user is represented by a famous cartoon character who rides a unicorn; player must collect healthy foods and avoid junk foods to reach the next level; gives nutrition tips Categories: nutrition education, exposure to fruits and vegetables
Kiddy Keep Fit by Scotty & Lulu Behavioral index score: 2 Strategy index score: 1	Rating not available	Free	Sing, dance, and move along with musical cartoon characters; app features game where user taps the screen as quickly as possible to get the cartoon character to jump; user can play another user or the app. Categories: movement-powered app
Food Find Behavioral index score: 3 Strategy index score: 0	2 stars 9 reviews	Free	This game app uses satellite technology; a group of users collect virtual health food items by moving in real space. Users can compete with their friends. Categories: exposure to fruits and vegetables, movement-powered app
Super Stretch Yoga Behavioral index score: 2 Strategy index score: 1	5 stars 11 reviews	\$1.99	User does yoga along with the characters. Categories: exercise education, exercise demonstrations/instructions, movement-powered app
uSwim: Teach kids to swim Behavioral index score: 1 Strategy index score: 2	Rating not available	Free	App to be used by parents; provides videos and instructions on how to teach children to swim Categories: exercise demonstrations/instructions, exercise education
Mr Fruitness: Learn and Cut Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	Video game where users virtually cut fruit while avoiding junk food; nutrition tips provided Categories: nutrition education, exposure to fruits and vegetables
FitQuest Lite Behavioral index score: 2 Strategy index score: 0	4.5 stars 37 reviews	Free	In this game app, user jogs, hops, jumps, and ducks in real life to move the game character and get to the next level. Categories: movement-powered app

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Table 2. Name, Behavioral, and Strategy Index Scores, Popularity, Price, Description, and Category for Each of the 62 Apps Included in the Study, Listed by Combined Behavioral and Strategy Index Scores in Descending Order *continued*

App name	Popularity (1–5 stars)	Price	Description
Move Like Me Behavioral index score: 2 Strategy index score: 0	4 stars 7 reviews	\$1.99	In this game app, user hops, claps, marches, and sways along with an animated bear; user recalls the order of movements to win each level. Categories: exercise demonstrations/instructions, movement-powered app
Motion Maze Trick or Treat Behavioral index score: 2 Strategy index score: 0	4 stars 8 reviews	Free	User's real movement powers a game character through a maze; apps feature levels of increasing difficulty. Categories: movement-powered app
Pop & Dodge Behavioral index score: 2 Strategy index score: 0	3 stars 7 reviews	Free	User jumps in real life to avoid virtual dodge balls in this game app. Categories: movement-powered app
Motion Maze Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	User's real movement powers a game character through a maze; apps feature levels of increasing difficulty. Categories: movement-powered app
Simon Says Jump Lite Behavioral index score: 2 Strategy index score: 0	2.5 stars 12 reviews	Free	Narrated Simon Says game to be played alone or with friends. Categories: movement-powered app
Stretch Break for Kids Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	App prompts users to take stretch breaks and gives video demonstrations and instructions for stretching. Categories: exercise demonstrations/instructions
Motion Maze Holiday Adventure Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	User's real movement powers a game character through a maze; apps feature levels of increasing difficulty. Categories: movement-powered app
Fat Jump Behavioral index score: 2 Strategy index score: 0	4 stars 378 reviews	Free	Video game where user must collect healthy foods and avoid junk foods to get to the next level. Categories: exposure to fruits and vegetables
Freeze Dance Behavioral index score: 2 Strategy index score: 0	4.5 stars 13 reviews	\$0.99	This game app is designed for a group of users. The app uses music stored on user's phone; music starts and players dance, music stops and players freeze. The rules of the game resemble musical chairs. Categories: movement-powered app
Hula Hooping for Beginners Behavioral index score: 2 Strategy index score: 0	Rating not available	\$2.99	Hula hoop instructional videos with fitness tips. Categories: exercise education, exercise demonstrations/instructions
Real Food Moms Recommendations Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	App to be used by parents; provides healthy recipes and nutrition tips. Categories: nutrition education, meal planning
Fat Jump Pro Behavioral index score: 2 Strategy index score: 0	Rating not available	Free	Video game where user must collect virtual healthy foods and avoid junk foods to get points and make it to the next level. Categories: exposure to fruits and vegetables
Learning Colors with Fruits Behavioral index score: 1 Strategy index score: 0	3 stars 22 reviews	\$0.99	Electronic book featuring fruits. Categories: exposure to fruits and vegetables, narrated book
Learning Colors with Vegetables Behavioral index score: 1 Strategy index score: 0	3.5 stars 8 reviews	\$0.99	Electronic book featuring vegetables. Categories: exposure to fruits and vegetables, narrated book
Fruits and Vegetables: An Early Introduction Behavioral index score: 1 Strategy index score: 0	3 stars 16 reviews	Free	Electronic book featuring fruits and vegetables. Categories: exposure to fruits and vegetables, narrated book
Charlie Wonders Milk Behavioral index score: 1 Strategy index score: 0	4.5 stars 90 reviews	\$0.99	Electronic book about milk production. Categories: nutrition education, narrated book

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Table 2. Name, Behavioral, and Strategy Index Scores, Popularity, Price, Description, and Category for Each of the 62 Apps Included in the Study, Listed by Combined Behavioral and Strategy Index Scores in Descending Order *continued*

App name	Popularity (1–5 stars)	Price	Description
Happy Kids Mixi Nutrition Behavioral index score: 1 Strategy index score: 0	Rating not available	\$0.99	This app includes puzzle games picturing fruits and vegetables. App includes levels of increasing difficulty. Categories: exposure to fruits and vegetables
Food Focus: Fruits Behavioral index score: 1 Strategy index score: 0	Rating not available	\$0.99	In this game app, user guesses type of fruit after seeing a close-up image. App includes levels of increasing difficulty. Categories: exposure to fruits and vegetables
Sprowt Out Behavioral index score: 1 Strategy index score: 0	Rating not available	Free	App allows users to play while being exposed to fruits and vegetables. User “dresses up” pictures of vegetables with different options of facial features and accessories. Categories: exposure to fruits and vegetables
The Dole Counting Book Behavioral index score: 1 Strategy index score: 0	Rating not available	\$3.99	Electronic book featuring fruits and vegetables Categories: exposure to fruits and vegetables, narrated book
Learn Gymnastics for Kids Behavioral index score: 1 Strategy index score: 0	4 stars 16 reviews	\$2.99	Gymnastics video demonstrations and instructions Categories: exercise demonstrations/instructions
Short Sequence: Kid’s Yoga Behavioral index score: 1 Strategy index score: 0	3.5 stars 28 reviews	Free	Narrated yoga instructions with pictures of the poses; includes an electronic book feature Categories: exercise demonstrations/instructions, narrated book
My First Yoga—Animal Poses Behavioral index score: 1 Strategy index score: 0	3 stars 18 reviews	Free	Pictures of cartoon children depict yoga poses and give narrated instructions. Categories: exercise demonstrations/instructions
Isshin-ryu Basic Exercises Behavioral index score: 1 Strategy index score: 0	Rating not available	\$0.99	Karate education and video instructions Categories: exercise demonstrations/instructions
FitDeck Junior Behavioral index score: 1 Strategy index score: 0	Rating not available	\$9.99	Exercise instructions presented on virtual cards Categories: exercise demonstrations/instructions
Appu’s Yoga For Kids Behavioral index score: 1 Strategy index score: 0	Rating not available	Free	Video-narrated yoga instructions with fitness education Categories: exercise education, exercise demonstrations/instructions, movement-powered app
I AM LOVE—Kid’s Yoga Journey Behavioral index score: 1 Strategy index score: 0	4.5 stars 45 reviews	\$1.99	Electronic book with yoga instructions Categories: exercise education, exercise demonstrations/instructions, narrated book
Hula Hoop Fitness Advance Behavioral index score: 1 Strategy index score: 0	Rating not available	\$1.99	Hula hoop video lessons Categories: exercise demonstrations/instructions
LazyTown AirShipChallenge Behavioral index score: 1 Strategy index score: 0	Rating not available	\$1.99	Video game where user flies a spaceship collecting healthy foods and avoiding junk food to reach the next level Categories: exposure to fruits and vegetables
Peckish Behavioral index score: 0 Strategy index score: 0	3 stars 9 reviews	Free	Users play this app by touching images of candy; user imagines eating it in order to “satisfy sugar cravings.” Categories: none
Shake Shake Pop Lite Behavioral index score: 0 Strategy index score: 0	2.5 stars 9483 reviews	Free	In this game app, user shakes their iPhone in order to make an imaginary soda bottle burst; app includes levels of increasing difficulty. Categories: movement-powered app
Healthy Food Alternatives Behavioral index score: 0 Strategy index score: 0	Rating not available	\$0.99	App to be used by parents; provides a list of “healthier” alternatives to common foods Categories: nutrition education
KidsRecipes Behavioral index score: 0 Strategy index score: 0	Rating not available	Free	App to be used by parents; provides recipes that appeal to children Categories: meal planning

ability to read. Flesch-Kincaid Reading Grade Level statistics were performed on the apps where reading was partially or completely required. The average Flesch-Kincaid Reading Grade Level was 6.8 for apps that were partially functional without reading and 5.9 for apps that required reading.

Categories. Apps encompassed eight primary functions and were grouped into the following categories: Exposure to Fruits and Vegetables; Exercise Demonstrations/Instructions; Movement-Powered Apps; Nutrition Education; Diet and/or Exercise Log; Exercise Education; Narrated Book; and Meal Planning. Many apps fell into more than one category. Only one app did not fit into any of the eight categories. This app showed an image of candy pieces and prompted users to imagine eating the candy, thereby claiming to satisfy sugar cravings without the actual consumption of sweets.

Exposure to fruits and vegetables. Nearly half (40.3%) of apps fell into this category. These apps featured images of fruits and vegetables. Many, but not all, of the apps that fell into the exposure to fruits and vegetables category also fell into the nutrition education category. Those that fell exclusively into the exposure to fruits and vegetables category showed images of fruits and vegetables, but did not provide any educational information; these apps were appropriate for very young children. Many of these apps included virtual worlds (virtual grocery stores, rocket ships flying through food-littered space, mazes, road/race courses, and so on) where the child is asked to virtually “collect” or “select” healthy foods (e.g., fruits and vegetables) and “avoid” junk foods (e.g., soda, candy). The selection of healthy foods is reinforced in various ways—for example, positive sounds, verbal reinforcement, game points, or other rewards, such as virtual stickers, and the selection of bad foods is signaled by the loss of points in a game, harsh buzzing noises, and verbal reminders that junk foods are bad. No previous knowledge of good and bad foods is required and instructions are not necessary; rather, the child can learn to distinguish good and bad foods by playing the app.

Exercise demonstrations/instructions. Twenty-nine percent of apps fell into this category. These apps used videos, pictures, and/or narrations to show the user how to perform certain exercises. Many of these apps require no reading ability in order to work the app and mimic the movements. However, some of these apps have additional reading components available, and exercises such as gymnastics, crunches, and pull-ups are demonstrated, making many of these apps more appropriate for older children.

Nutrition education. Some (27.4%) of the apps fell into this category. These apps provided the user with nutrition facts, tips, and recommendations. For example, in one game app, when soda is accidentally collected by the player’s avatar, the app says, “soda zaps your energy” and the avatar loses energy points necessary to make it to the next level;

when oranges are collected, the app says, “oranges for energy!” and the avatar gains energy necessary to make it to the next level. These are spoken tips that require no reading ability. However, other apps that fall into the nutrition education category provide written nutrition information, such as, “Vegetables are rich in vitamins and a good way to protect your heart.” Another reads, “Brown rice is a whole grain and has more nutrients than white rice.” Another reads, “Cherries are a good source of vitamin C and potassium.”

Movement-powered apps. Some (22.5%) of the apps fell into this category. These apps required user movement (jumping, walking in place, or jogging) to power the app or prompted the user to move along with characters depicted in the app. In the majority of these apps, the user holds the phone in their hand while performing the actions, and the smartphone detects the movement and animates the user’s avatar through a virtual game world. For example, in one app, the more vigorously the user jogs in place, the more successfully their avatar makes it through the game level. In most cases, the user receives reinforcement in the form of either verbal praise/encouragement or level completion for doing the required movement. Simple verbal instructions (jump or run in place) that even a young child could understand are given, although a child would need to have the motor skills necessary to perform these tasks.

Exercise education. Some (14.5%) of the apps fell into this category. These apps provide information about the benefits or simple physiology of exercise, for example, “exercise is good for your heart,” or “exercise calms your mind and gives you energy for the rest of your day,” or “this stretch will help get air to your brain.” No app fell exclusively into this category. This category most often occurred along with the exercise demonstration/instruction category. However, several apps fell into the exercise demonstration/instruction category without providing any information about exercise other than the visual/video aids for the mimicking of movements.

Diet/exercise logs. Some (14.5%) of the apps fell into this category. These apps prompted the user to record their diet and/or exercise behaviors. Apps that fell into this category were usually intended for older children who must understand the concepts of energy balance, calorie and energy expenditure tracking, self-monitoring, and more abstract elements of nutrition. Users were asked to identify the foods they ate and/or exercises they did each day and were sometimes given calorie input output information. However, in one case, young children did not need to read and could plan their meals based on photos of healthy foods they could simply drag into a virtual lunch box.

Narrated books. Some (12.9%) of the apps fell into this category. These apps were illustrated electronic books with narration and included nutrition and/or exercise themes. These apps usually included simple information—for

example, “apples are red,” “fruits and vegetables will help you grow up to be healthy and strong,” and “junk food choices are sometimes wrong”—that could be understood by younger children. The exception was an app that told a more complex story about where milk comes from. Though children of any age could still listen to the story, very young children may not fully comprehend all the spoken facts.

Meal planning. Some (11.2%) of the apps fell into this category. These apps prompted users to plan healthy future meals. Most of these apps were designed for use by parents. However, there were some exceptions. For example, one app allowed children to virtually shop in a grocery store. They could choose different foods to go in their cart; they were cheered for choosing healthy items and not allowed to add junk food to the cart. The whole app was animated and had no written language.

Many of the apps from different categories utilized a game format. Of the apps designed for children, 42.5% utilized a game format. As with video games, these apps allowed for interactive play and had scoring systems and

internal game goals that lead to obtaining points and completing levels. Other apps allowed users to play (*e.g.*, dress up pictures of vegetables or go virtual grocery shopping), but were not formatted as games (no internal goals, levels, or points). Apps designed for children that did not use a game format or allow for play most often fell into the categories of exercise logs, narrated books, and exercise demonstrations/instructions.

Behavioral and strategy index scores. Behavioral index scores had a potential range of 0–30 and an actual range of 0–26. Although the mean behavioral index score was low (3.5), 53.2% of the apps scored a 2 or 3 in at least one of the 10 behavior categories, meaning that they promoted at least one of the recommended behaviors at a moderate or high level. Strategy index scores had a potential range of 0–4 and an actual range of 0–3. Similarly, the mean was low (0.48), but 20.9% of the apps used at least one of the recommended strategies. As can be seen in Table 3, apps encouraged certain target behaviors, namely, engaging in physical activity (53.2%) and eating fruits and vegetables

Table 3. Percentage of iPhone Apps That Promoted the Expert-Recommended Behaviors and Strategies for the Prevention of Pediatric Obesity²⁷

Recommended behavior				
	Total (%)	Promoted “weakly” 1 (%)	Promoted “moderately” 2 (%)	Promoted “strongly” 3 (%)
Get 1 hour of physical activity per day ^a	53.2	14.5	35.4	3.2
Eat five fruits and vegetables per day	48.3	27.4	19.3	1.6
Switch to low-fat dairy products as part of a diet rich in calcium ^a	24.1	8	9.6	6.4
Eat a high-fiber diet	22.5	6.4	3.2	12.9
Limit consumption of sugar-sweetened beverages ^a	12.9	4.8	3.2	4.8
Limit fast food, take-out, and eating out	11.2	9.6	0	1.6
Eat breakfast daily	9.6	4.8	0	4.8
Prepare foods at home as a family	6.4	3.2	0	3.2
Limit screen time to less than 2 hours per day	1.6	0	0	1.6
Regularly eat family meals together	1.6	0	0	1.6
Recommended strategy				
	Utilized strategy (%)			
Self-monitoring	16.1			
Positive reinforcement	14.5			
Goal setting	11.2			
Cognitive restructuring	6.4			

^aAs a function of rounding, total percentages are not equal to the sum of subscores.

(48.3%) at a relatively high frequency, whereas other target behaviors, such as eating family meals together (1.6%) or limiting screen time (1.6%), were rarely encouraged by existing apps. Although none of the strategies were widely used, self-monitoring (16.1%) was the most common strategy addressed by existing apps.

The app with the highest index scores (behavioral index score = 26; strategy index score = 3) was an app designed by the AAP, from whose recommendations our coding system was derived. The main function of the app was as a workout aid. The app provided video demonstrations of exercises and aided the user in the creation of a custom workout schedule. In line with the recommended strategies, the app asked its users to set goals, prompted them to monitor their own progress, and encouraged focus on successes. This was the only app that addressed the recommended behavior of limiting screen time. As can be seen in Supplementary Table 1 (see online supplementary material at www.liebertpub.com/chi), the app fell short of a perfect score by failing to explicitly discourage the consumption of fast food as well as by neglecting one of the four strategies—positive reinforcement. Last, whereas the app recommended that children eat fruits and vegetables every day, it did not explicitly recommend five servings per day. This app was partially functional without reading (*i.e.*, young children could watch instructional videos leading them in exercises, but could not read the health articles linked to the app) and had a Flesch-Kincaid Reading Grade Level of 6.8.

WakeMyMojo, the app with the second-highest behavioral and strategy index scores (behavioral index score = 16; strategy index score = 2), was primarily a diet, exercise, and mood log. Users were encouraged to exercise and eat healthy foods, given a wide range of health tips, and were implicitly prompted to look for patterns that arose in their moods as a result of their health behaviors. The app strongly or moderately promoted 6 of the 10 target behaviors and utilized two of the four recommended strategies. This app required reading to operate, although the Flesch-Kincaid Reading Grade Level was 1.8, such that users with a second-grade education or higher should be able to read and comprehend information contained in the app.

Discussion

The aim of this study was to analyze the content of available children's nutrition and exercise iPhone applications while measuring their adherence to expert-recommended guidelines for the prevention of pediatric obesity. Sixty-two applications were assessed for their promotion of expert-recommended target behaviors (*e.g.*, limit consumption of sugar-sweetened beverages) and strategies (*e.g.*, self-monitoring).²⁷ Our main finding was that overall adherence to the full list of evidence-based guidelines for pediatric obesity prevention was low, but that apps supporting certain expert-recommended behaviors and strategies are available to varying degrees. Two important behaviors, consumption of fruits

and vegetables and physical activity, were addressed regularly, and the majority of apps promoted at least one of the recommended behaviors to a moderate or high degree.

Apps were also strong in their use of stealth interventions—interventions where the target outcome is a side effect, but not the primary motivator, of participation.³⁰ In obesity prevention, stealth interventions are those in which physical activity and/or health education are side effects of engagement in another behavior.³⁰ A study at Stanford University randomly assigned adolescent girls to take part in either a dance class or a standard physical education class. Not surprisingly, the girls in the dance class, motivated by fun and social stimulation, experienced greater health gains and a higher degree of health behavior change.³⁰ Other studies examining stealth interventions in adults have shown that health behavior change is more likely when the primary motivators for the change are social, ethical, or environmental, as opposed to directly related to personal health (*e.g.*, riding one's bike to work to decrease one's carbon footprint).^{31,32} In the case of these children's apps, stealth interventions were most commonly accomplished through a game format. Children are intrinsically motivated to play games, but are not intrinsically motivated to exercise for weight loss or learn about healthy diet and exercise behaviors. As a result, children played the games for fun and burned calories/learned about proper diet and exercise "accidentally." When health education and/or exercise are built into a game format, children are more likely to enjoy the intervention and, as a result, more likely to engage in target behaviors (*e.g.*, exercise and eat healthily) and reach the target outcome (*e.g.*, decreased overweight and increased health). Knowing what we know about human motivation and health behavior change, future app developers should take advantage of the proven efficacy of stealth interventions for pediatric obesity prevention and treatment.^{4,30–33}

A closer look at our findings shows that though there are many positive aspects in the existing apps, there are some common shortcomings that, if addressed, would greatly add to the efficacy of this technology. Namely, a greater degree and depth of target behavior promotion and the increased implementation of recommended strategies are needed. Our findings also show that "weak" promotion of target behaviors is prevalent; perhaps one of the simplest improvements that could be made in current apps would be to increase the strength of target behavior promotion. Often, a more direct recommendation of the target behavior would accomplish this. For example, instead of recommending "more" fruits and vegetables, recommend *five servings per day*. Though simple, this type of change could represent a significant improvement in app efficacy by guiding the goal-setting process in a meaningful way.

Currently available apps put a heavy emphasis on 2 of the 10 recommended behaviors, (physical activity and consumption of fruits and vegetables), whereas few apps address other crucial behavioral recommendations, such as

limit consumption of sugar-sweetened beverages and limit screen time to less than two hours per day. All of the expert-recommended behaviors are important, but lack of focus on screen time and sugar-sweetened beverages in particular, represents a major deficiency in the body of current apps.^{34–37} Although it is not necessary for every app to address all 10 recommendations, there is room for future app developers to focus on underrepresented target behaviors.

The largest shortcoming of the apps on the whole was a failure to include recommended strategies. To harness the full potential of smartphone technology, the ideal children's nutrition or exercise app would utilize all four of the recommended strategies, maximizing the likelihood of positive behavior change. There are several examples in the literature of successful implementation of these strategies in relevant formats. An article by Nollen and colleagues describes a hand-held computer program designed to increase fruit and vegetable (FV) consumption in young tween and teen girls.²² The program provided FV education, tips for increased FV consumption, and FV recipes. The program required the girls to set FV intake goals and record their daily FV intake in a diary and positively reinforced continued use of the hand-held computers through a music download reward system. Similar studies by Woolford and colleagues and Shapiro and colleagues have described text-messaging-based approaches to self-monitoring and positive reinforcement, finding that children like and respond to these approaches.^{38,39} Notably, these studies have depended on outdated or age-dependent technology, but they demonstrate the potential of apps to integrate these strategies and provide models for how empirically based smartphone apps could function as behavior change tools.

Many apps received low behavioral index scores as a result of their focus on a specific health behavior or a small number of specific health behaviors. For example, one app encouraged users to try healthy foods, gave information about the nutritional benefits of a wide variety of fruits and vegetables, and rewarded users with virtual stickers when they tried a new food from each category. Because this app did not encourage a large number of the target behaviors, it received a behavioral index score of 6 of 30. However, the app promoted important aspects of nutrition (increased consumption of fruits and vegetables, low-fat dairy, and fiber) by means of three of the four recommended strategies: positive reinforcement; cognitive restructuring; and self-monitoring. Behavioral and strategy index scores provide information about each individual app's adherence to the *full* list of expert-recommended behaviors and expert-recommended strategies and, taken as a whole, general information as to what is currently available on the market. Though these scores can be used as a partial value assessment for apps, higher index scores will not always signify a more valuable or effective intervention. Apps that focus on strong promotion of a small number of health behaviors are not necessarily less valuable than apps that

address a greater number of health behaviors. But, clearly, apps that do not utilize at least one target strategy while simultaneously promoting at least one target behavior are less likely to be effective tools for childhood obesity prevention.

Study Limitations

Several limitations of the study should be noted. Analysis was limited to iPhone apps only, frequency of download information was not available, and although effort was made to identify all apps in the realm of children's nutrition and exercise, additional apps are added to iTunes regularly. Perhaps most significantly, apps were not analyzed for usability/heuristic value (*i.e.*, how engaging they were to children) or efficacy (*i.e.*, can they change behavior). Subsequent research should consider these important areas of future study. Accordingly, the highest-scoring apps were not necessarily the best liked or most effective, but were the apps that (1) promoted the greatest number of recommended strategies and (2) recommended the greatest number of target behaviors in the most complete and direct manner. Further, whereas our findings suggest a reasonable degree of consistency between user ratings/satisfaction and app adherence to expert guidelines, the iTunes user-derived star ratings found in Table 2 should not be considered a substitute for an assessment of usability or heuristic value, in large part because the apps for children were most likely rated by the parents, not the target population.

Recently, a health app certification service became available through the organization, Happtique. In order to obtain certification, an app must meet clearly defined content, operability, security, and privacy standards. App certification is for-cost and submission must be made by the app developer; therefore, this service could not be used to assess apps in this study. However, future app developers should consider using these certification standards when developing obesity prevention apps; having apps certified will increase credibility and adherence to evidence-based standards.⁴⁰ Whereas the certification of an app will guarantee the accuracy of its content and the appropriateness of the app for its target audience, it will not guarantee the efficacy of the app's format, its usability, or its heuristic value.

Conclusion

With notable exceptions, many of today's children's health apps have been designed without expert recommendations in mind and, therefore, are unlikely to be valuable tools in health behavior change. With proper evidence-informed design, children's nutrition and exercise apps are in a position to make an impact in the realm of obesity prevention. However, though the use of evidence-based recommendations is a vital aspect of app efficacy, alone, it does not measure an app's potential as an instrument of behavior change. If an app fails to engage its users

over the long term, it will not be an effective behavior modification tool. Future app analysis should include a more complete measure of app efficacy that includes usability, heuristic value, and user engagement. The challenge for future developers will be to create apps that are empirically based and address expert recommendations while simultaneously keeping their young audience engaged.

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