The FIT Game III: Reducing the Operating Expenses of a Game-Based Approach to Increasing Healthy Eating in Elementary Schools

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Abstract

Objective: Previously published versions of the healthy eating “FIT Game” were administered by teachers in all grades at elementary schools. The present study evaluated whether the game would retain its efficacy if teachers were relieved of this task; presenting instead all game materials on visual displays in the school cafeteria.

Materials and Methods: Participants were 572 children attending two Title 1 elementary schools (grades K-5). Following a no-intervention baseline period in which fruit and vegetable consumption were measured from food waste, the schools played the FIT Game. In the game, the children’s vegetable consumption influenced events in a good versus evil narrative presented in comic book-formatted episodes in the school cafeteria. When daily vegetable-consumption goals were met, new FIT Game episodes were displayed. Game elements included a game narrative, competition, virtual currency, and limited player autonomy. The two intervention phases were separated by a second baseline phase (within-school reversal design). Simulation Modeling Analysis (a bootstrapping technique appropriate to within-group time-series designs) was used to evaluate whether vegetable consumption increased significantly above baseline levels in the FIT Game phases ($P < 0.05$).

Results: Vegetable consumption increased significantly from 21.3 g during the two baseline phases to 42.5 g during the FIT Game phases; a 99.9% increase. The Game did not significantly increase fruit consumption (which was not targeted for change), nor was there a decrease in fruit consumption.

Conclusion: Labor-reductions in the FIT Game did not reduce its positive impact on healthy eating.

Keywords: Children, Nutrition, School-based intervention, Fruit and vegetable, Consumption

Introduction

HEALTH ORGANIZATIONS recommend that school-aged children consume at least two to three cups of fruits and vegetables (FV) per day¹ because (1) each additional serving of FV consumed daily is associated with a 5% reduction in all-cause adult mortality²; (2) consuming FV is associated with prevention of cancer, diabetes, and cardiovascular disease^{3–5}; (3) consuming more and a wider variety of vegetables is associated with lower levels of body fat in male children,⁶ and (4) children’s dietary habits carry on into adulthood.^{7–10} Although the benefits of FV consumption are commonly known, the majority of U.S. children do not ad-

here to these recommendations;¹¹ this is particularly true of vegetables, with fewer than 10% of U.S. children consuming recommended levels of vegetables each day.¹²

Since the 2012 reform of the U.S. National School Lunch Program, a greater amount and wider variety of FV are served in public school cafeterias.¹³ Thus, schools are ideal locations in which to encourage healthy eating.¹⁴ Within schools, incentives have proven to be among the most effective means of encouraging FV consumption.^{15–22} However, incentives have features that may limit their acceptability.¹⁴ Schools may be unable, or unwilling to purchase incentives. Incentive systems must be managed, and schools may object to this labor reallocation. Educators may object to extrinsic rewards, citing

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unintended effects on intrinsic motivation,²³ and incentives may induce children to cheat.²⁴ These shortcomings limit the practical utility of incentive-based healthy eating programs.

Games offer a potentially inexpensive medium in which to encourage healthy eating.²⁵ Much of the game-based research targeting healthy eating uses videogame platforms.^{26,27} An exception to this rule is a school-based game which, in two pilot studies, has increased elementary-school children's FV consumption by 61.5%²⁸ and 56.5%²⁹; these increases are comparable to interventions using tangible incentives.²¹ This game-based intervention, known as the FIT Game, employs several game-design elements.³⁰ It provides a compelling narrative in which heroes (partially under the school's control) compete against virtual opponents, and earn virtual currency, all in the service of achieving the object of the game—to capture a band of villains. Importantly, events happening daily within the narrative are dependent upon the school meeting a healthy-eating goal. In this way, the FIT Game incentivizes FV consumption with virtual, game-based outcomes.

In past FIT Game studies, after the school met its daily healthy-eating goal, teachers read a game episode that revealed how the school's healthy eating helped the heroes overcome an obstacle, capture a villain, earn virtual currency, and so on. On days when the goal was not met, a brief message was read, encouraging children to try harder. The task of reading these episodes fell on teachers, who were asked to retrieve the episodes from email or their school mailboxes, schedule the reading into their normal academic routine, and present the episodes in a way that children would find compelling. In these studies, teachers occasionally did not read the episodes as scheduled (they reported forgetting to do so) and a few teachers complained about the daily interruption of their classroom activities (e.g., it took time away from academics).^{28,29}

This study was conducted to evaluate the efficacy of a more labor-efficient, less disruptive, and foolproof version of the FIT Game. Instead of asking many teachers to interrupt their daily routine and remember to read a FIT Game episode, episodes were presented by a single study-personnel member, in comic book format on a central display in the cafeteria. In addition to the previously used game elements (narrative, partial autonomy, competition, and virtual currency), in this study children were periodically given the opportunity to solve riddles that impacted events within the game narrative. This project was conducted in two Title 1 (low income) elementary schools. The lunchtime dietary behavior targeted for improvement was vegetable consumption. Vegetables were selected to provide a stringent evaluation of the low-labor version of the FIT Game. That is, vegetables are rated less favorably than fruit among elementary school-aged children³¹ and vegetable consumption is less likely than fruit consumption to change in the face of healthy-eating interventions.³² We hypothesized that presenting the FIT Game materials in the cafeteria would significantly increase vegetable consumption.

Methods

Participants

Schoolchildren in Kindergarten through fifth grades (ages 5–11) attending two low-income Title 1 elementary schools in Cache County, UT were invited to participate using a passive

consent procedure. All students and their parent/guardian consented; 278 students in the first school and 294 in the second. All procedures were reviewed and approved by the Institutional Review Board overseeing the authors' research.

Materials

The FIT Game narrative was presented in daily comic book-formatted episodes on a central display in the school cafeteria. In one school (School P), the episodes were printed on posters measuring 91×69 cm. In the second school (School I), the episodes were presented as images projected onto a screen (~4×4 m) in the cafeteria.

A scale with a resolution of 1 g (Ozeri, San Diego, CA) was used to measure the weight of individual FV portions. Two 37.9 L capacity bins, one red and the other green, were used to collect children's FV waste. A floor scale (180-kg capacity, 0.1-kg resolution; EatSmart, Mahwah, NJ) was used to measure FV waste collected in these bins. On days when students chose the direction of the FIT Game narrative, a poster-board (55.9×71 cm, delineated with spaces for marking a vote) was affixed to a wall with pencils tied to strings.

Assessment of FV Intake

Lunchtime FV intake of children eating school-provided lunch was assessed using a plate-waste measurement technique.^{28,29} Before lunch, study personnel separately recorded the weight of all fruits and all vegetables prepared; the amounts not served were also recorded after lunch. After students eating school-provided lunch had eaten, they took their lunch tray to a waste station where, under the supervision of study personnel, they separated their FV waste into red and green bins, respectively. Children who brought lunch from home did not place their FV waste into these bins. After lunch, the contents of the bins were separately weighed. The per-student average amount of FV consumed each day was calculated using Equation 1:

$$\text{Consumption} = \frac{P_V - U_V - W_V}{N} \quad (\text{Eq.1})$$

where P_V is the weight of all vegetables prepared, U_V represents the weight of any unserved vegetables, W_V is the weight of the vegetable waste, and N is the number of students who ate school-provided lunch. Equation 1 was also used to measure average fruit consumption, with fruits weights substituted in the numerator.

Procedures

Design. An A-B-A-B reversal design was used, with "A" referring to the no-intervention baseline phases and "B" referring to the FIT Game intervention phases.³³ The intervention was completed in the Spring, 2015 semester in School P and the Spring, 2016 semester in School I. No changes to the school lunch menu were made.

Baseline I. During the 10 days of Baseline I, children sorted their FV waste into the waste bins. They received no feedback about the amounts of FVs consumed.

FIT game phase I. Phase I lasted for 10 days in School I and for 16 days in School P. The shorter phase duration in School I reflects (1) the occasional combination of multiple poster episodes displayed in School P into a single projected-image episode in School I, and (2) decreasing the duration of the inter-school competition (described later in this paragraph) in School I. Phase I began by introducing children to the fictional heroes of the game (the FITs; top panel of Fig. 1) and the object of the FIT Game: to help the FITs capture the leaders of the Vegetation Annihilation Team (VAT; bottom panel of Fig. 1). Table 1 outlines the important characteristics of the FIT Game and provides a synopsis of the narrative arc of the game. This information was provided in a script read either at a school-wide assembly (School P) or in the classroom by teachers (School I). The script ended by describing a competition in which different (fictional) schools would compete to see which school could eat the most vegetables. During the competition, when the school collectively met or exceeded a daily lunchtime vegetable-consumption goal (de-

scribed in the next paragraph), cafeteria displays (posters in School P, and projected images in School I) informed children that a school had been defeated.

Throughout the FIT Game, the daily vegetable-consumption goal was to consume at or above the 60th percentile of the school's own lunchtime vegetable consumption over the previous 10 days.³⁴ This algorithm was used daily to update the goal. In this way, the goal was gradually increased (decreased) when the goal was consistently met (not met). Children were not informed how the goal was calculated, they were simply encouraged to meet the goal by eating a little more than normal. New posters/images were presented on days after the vegetable-consumption goal was met. When goals were not met, the next poster/image encouraged the children to try again. When goals were exceeded, game currency (FIT Points) was earned at a rate of one point per gram by which the goal was exceeded. For example, if the goal was to consume 31 g of vegetables and the average student consumed 33 g, then two FIT Points were added to the display.

FIG. 1. FIT Game characters.

TABLE 1. CHARACTERISTICS OF FIT GAME: AN INTERACTIVE GAME PLAYED AT THE SCHOOL-LEVEL
BY CHILDREN ATTENDING ELEMENTARY SCHOOLS

Health topic	Vegetable consumption
Targeted age group	6 to 11 years
Other targeted group characteristics	Attending a Title 1 public school
Target players	Elementary school students
Guiding knowledge or behavior change theories, models, or conceptual frameworks	Instrumental learning: Eating vegetables earns new episodes and in-game rewards (e.g., virtual currency).
Intended health behavior changes	Increasing consumption of vegetables
Knowledge elements to be learned	The game has no educational components. It incentivizes vegetable consumption with episodes and virtual rewards. The game seeks to create new healthy eating habits and increase consumption from repeated tasting of vegetables.
Clinical or parental support needed?	None
Data shared with parent or clinician:	Parents and teachers were provided with information about how the game had increased vegetable consumption at school.
Type of game	Adventure
Story	
Synopsis (including story arc)	Children were informed that they had been identified by the FITs as a school that could eat quite a few vegetables. They were invited to compete with other, fictional, schools to earn the right to play the FIT Game. After defeating these schools, the story arc was launched: The FITs are trying to find and capture three villains who represent the leadership of the VAT. The VAT destroys plant life of planets that they visit. The narrative begins when the FITs have tracked the first villain to a planetary system. With assistance from the participating school (the form of the assistance is meeting daily vegetable-consumption goals) the FITs capture the first villain. The villain proposes a deal—solve his riddle and he will divulge the location of the second villain (fail to solve it and let him free). Having solved the riddle and learned the location of the second villain, the FITs must travel through a wormhole. Inside the wormhole the FITs path is blocked by worms that require payment (in FIT Points that the school has heretofore earned by exceeding vegetable-consumption, goals) or decoding a message. Once through the wormhole, the second villain is found and captured. This angers the leader of the VAT who declares his intention to travel to Earth to stop the school from offering assistance to the FITs. Once on Earth, the villain reveals his plot to discourage FV consumption at the school. When the school meets its vegetable-consumption goals, the villain's plan is gradually foiled. The FITs purchase equipment with the schools' remaining FIT Points and flush the villain out of several hiding places at the school (e.g., the boys's bathroom). The villain is finally captured.
How the story relates to targeted behavior change:	It is more accurate to say that behavior change influences the story. When children at the school met their daily vegetable-consumption goals (behavior change), fictional schools were defeated (first 2–5 days), the game narrative continued, and FIT Points were earned (remainder of the game). On some days, children's votes determined the direction of the narrative. When children at the school did not meet the daily vegetable-consumption goal, the narrative was paused until the children met the goal.
Game components	
Player's game goal/objectives	Defeat fictional schools in the qualifying round. Thereafter, find and capture the 3 villains.
Rules	Meet a daily vegetable-consumption goal and the game continues, FIT points are earned, etc.
Game mechanic(s)	
Procedures to generalize or transfer what's learned in the game to outside the game	Again, this is not an education-based game. Learning to consume vegetables occurs in the real world with virtual consequences within the game.
Virtual environment	
Setting	Space, planets, inside space ships.
Avatar	None
Characteristics	NA
Abilities	NA
Game platforms needed to play the game	FIT Game materials were presented in the cafeteria on a poster in one school and with PowerPoint projections in the other school.
Sensors used	Scales were used to measure vegetables prepared, vegetables thrown away, and unserved vegetables.
Estimated play time	Each episode took about 2 minutes to view. There were 14 episode in School I and 20 episodes in School P. Thus, estimated play time was 28–40 minutes.

FIT, Field Intensive Trainees; FV, fruits and vegetables; NA, not applicable; VAT, Vegetation Annihilation Team.

After the competition (two days in School I, five days in School P), the object of the game shifted to capturing the villains. When vegetable-consumption goals were met, new narrative episodes were presented. The episodes employed several game elements. Every episode included the good versus evil game narrative and gave the school the opportunity to earn FIT Points (Narrative + Currency). Other episodes added the opportunity to solve riddles posed by characters within the narrative (Narrative + Riddles), while other episodes gave children the opportunity to vote on the direction of events happening in the episodes (Narrative + Autonomy). On these days, students voted at an unsupervised voting area.

Baseline II. During Baseline II, all display materials were removed from the cafeteria and data collection continued as before. This phase lasted for six days in School I and four days in School P.

FIT game phase II. In Phase II, the game was reinstated and conducted as in the postcompetition portion of Phase I; that is, new episodes continued the narrative and provided the school opportunities to earn currency, solve riddles, and vote on the direction of the narrative. Phase II lasted for four and six days in Schools I and P, respectively. In the final episode, the leader of the VAT was captured and the school was declared the victor.

Statistical analysis. To evaluate the effects of the FIT Game on FV intakes, a Simulation Modeling Analysis (SMA) was used to determine whether consumption during the FIT Game phases significantly differed from the preceding baseline phase. The SMA is appropriate for short time-series data because it considers autocorrelation, whereas repeated measures analysis of variance (ANOVA) does not.³⁵ Briefly, the SMA obtains a correlation coefficient between the obtained time-series data and dummy-coded baseline and intervention phase vectors. It then estimates autocorrelation in the obtained baseline and intervention phases, corrects for small-*n* bias,³⁶ and then randomly generates 5000 time-series data streams with the same autocorrelation and the same number of observations in each phase as the observed data. The proportion of randomly generated data streams with a correlation coefficient (against the phase vector) greater than or equal to the obtained correlation coefficient serves as the *P*-value. Where differences were statistically significant, effect sizes were estimated using Cohen's d_{av} .³⁷

Results

Figure 2 shows the between-school average (± 1 SEM) grams of FV consumed per child. During Baseline I, children consumed an average of 57.6 g of fruit (leftmost open bar in the fruit section of Fig. 2) and 21.7 g of vegetables (leftmost open bar in the vegetables section). In neither school was there an increasing trend in fruit ($P_s > 0.26$) or vegetable ($P_s > 0.14$) consumption over Baseline I; indeed, the slopes were nonsignificantly negative in both schools. Thus, without an intervention, neither fruit nor vegetable consumption would be predicted to increase.

During Phase I, vegetable consumption increased by 69% to an average of 36.8 g per child per day (leftmost filled bar in the vegetables section of Fig. 2). Vegetable consumption

FIG. 2. Amount of fruits and vegetables consumed during baseline and while playing the game by school ($n=2$).

significantly increased in School P ($R=0.61$, $P=0.05$, $d_{av}=0.74$) and School I ($R=0.34$, $P<0.05$, $d_{av}=0.76$). Fruit consumption, which was not targeted for improvement, nonsignificantly increased to an average of 74.9 g per child per day (+30%; School P: $P=0.14$; School I: $P=0.25$).

During Baseline II (second open bar in the fruit and vegetable sections of Fig. 2), fruit (57.9 g) and vegetable (20.5 g) consumption declined, with no significant difference from Baseline I in either dependent measure at either school ($P_s > 0.21$). When the game resumed in Phase II, vegetable consumption increased from Baseline II by 181% to an average of 57.5 g per child per day (School P: $R=0.98$, $P=0.0001$, $d_{av}=8.84$; School I: $R=0.81$, $P=0.03$, $d_{av}=2.44$). Fruit consumption increased in Phase II by 38.5% to 80.2 g. While this increase approached significance in School P ($R=0.75$, $P=0.06$) it was nonsignificant in School I ($P=0.77$).

Figure 3 shows the percentage of days on which the school met its vegetable-consumption goal, separated by the game element active on those days. The dotted line shows the chance level of meeting the goal (40% because the goal was the 60th percentile of the prior 10 days' vegetable consumption). A binomial test was used to determine the probability of, by chance, meeting goals as often as they were met; see the inset *P*-values in Figure 3. The lowest percentage of goals met occurred during the competition at the

FIG. 3. Percent of time that daily goals were met with different game elements in play ($n=2$).

beginning of Phase I (66.7%), which was not significantly different from chance. Combining the good versus evil narrative with riddles (72.7%) and currency (75%) produced significantly better than chance outcomes. Although voting (i.e., the narrative + autonomy game element) did not increase success above chance levels, this is due to the small sample size ($n=4$ days across schools).

Discussion

Elementary school children significantly increased their vegetable consumption when they played the FIT Game. Where prior FIT Game studies reported that vegetable consumption increased by 44%²⁸ and 33%²⁹ when the narrative was read in the classrooms by teachers, the present study presented the narrative in comic book format in the cafeteria and vegetable intake increased by nearly 100% (averaged across schools and phases). Larger increases in vegetable consumption were observed in the final phase in the school that played the FIT Game longer (School P). The present study targeted only vegetable consumption for improvement and intervention-related increases in vegetable, but not fruit consumption were observed. The specificity of the treatment effect together with large increases above no-intervention baseline levels provides strong evidence that the FIT Game is responsible for the increases in vegetable consumption observed in both schools.

The present version of the FIT Game was implemented with minimal teacher involvement, almost no disruption of classroom activities, and nominal material costs. In school P, teachers implemented no portion of the FIT Game, whereas in School I they read the narrative for less than 6 minutes (cumulative). Despite this reduction in teacher labor, the FIT Game increased vegetable consumption more than in past studies.^{28,29} This increase was not due to the addition of riddles to the game, as goals were not met more frequently on days when this game element was present. Instead, the increase may be due to improved implementation fidelity. That is, in past studies, some teachers forgot to read the FIT Game episodes, whereas in the present implementation, one study personnel member arranged the poster/projected images each day. In this way the fidelity of implementing this primary component of the intervention was guaranteed. This task could easily be implemented by school staff, as it took less than 5 minutes a day. Alternatively, or perhaps in combination, the larger increase in vegetable consumption in this study could result from presenting FIT Game episodes in the cafeteria (where vegetable consumption occurs) instead of in the classroom. As the episodes included verbal prompts to eat vegetables, placing these prompts more temporally proximal to eating may have contributed to the increased vegetable consumption we observed.

The FIT Game uses virtual outcomes to incentivize healthy eating. Thus, it is worth briefly considering critiques of incentive-based approaches to changing behavior. Some of these critiques appear philosophical (e.g., incentives amount to bribery), whereas others may be objectively evaluated (e.g., extrinsic rewards reduce intrinsic motivation to engage in the desired behavior³⁸). Applied to healthy eating, the latter critique, known as the “overjustification effect,” predicts incentives will increase FV consumption while they can be earned, but when they are suspended children will consume less than they did before. Reviews of the healthy-eating

literature, however, provide little empirical support for this prediction.^{14,39} For example, one review reported that liking of *palatable* foods decreased below baseline levels when incentives were suspended; however, *consumption* of these foods did not decline.³⁹ Further, incentives had no negative effects on consumption *or* liking of unpalatable foods (like vegetables). In nine relevant studies published after this review, none provides evidence that incentive-produced increases in FV consumption decrease healthy eating below baseline levels when incentives are withdrawn.^{15,21,40–46} Instead, six of these studies report positive effects on consumption at follow-up assessments.^{21,41–45} Thus, little empirical evidence suggests that incentives reduce children’s intrinsic motivation to consume FV. To the contrary, the modal finding suggests the opposite.

If incentivizing FV consumption in schools is an effective method for promoting the development of long-term healthy-eating patterns, then barriers to their adoption and implementation should be addressed. In our experience with tangible incentive programs^{21,22} cost is the primary barrier to adoption. In one of the lowest cost, and objectively effective incentive interventions published to date, Hoffman et al.¹⁵ provided children with low-cost stickers (\$0.04 each) contingent upon consuming FV in the elementary school cafeteria. Although the stickers were inexpensive, distributing them contingent upon healthy eating required six lunchroom aids to monitor FV consumption. By contrast, the current version of the FIT Game used no-cost virtual incentives (e.g., FIT Points) and could be implemented by just one study personnel member.

Shortcomings of the FIT Game research conducted to date are (1) the lack of a lasting impact on FV consumption after the intervention is withdrawn, (2) the brief duration of the intervention, and (3) no data reported on individual participants’ FV consumption. After playing the FIT Game for 10–16 days, both of the current schools returned to a no-intervention baseline period and in both cases FV consumption returned to baseline levels. While this return to baseline FV consumption is optimal for demonstrating experimental control, it is not optimal if the goal is to impact long-term healthy eating. Increasing the duration of the FIT Game may produce longer-lasting effects if, during this time, children repeatedly taste previously avoided foods.^{47,48} Longer-duration incentive-based interventions have increased FV consumption when evaluated 2 to 12 months after the intervention concludes.^{17,21,41,44,45} Thus, increasing the duration of the FIT Game should be a priority for future research.

Regarding the final shortcoming, only one unpublished study has evaluated the effects of the FIT Game on individual children’s FV consumption.⁴⁹ In that unpublished study, top-down photos were taken of 156 children’s cafeteria trays before and after they ate lunch. The photos were subsequently scored by independent observers, estimating the amounts of vegetables consumed by comparing the before and after-lunch amounts in the photos.²¹ On the two days in which the FIT Game targeted vegetable consumption, the ANOVA revealed a significant phase $\times$ baseline-consumption interaction ($F_{(1,155)}=17.89$, $P<0.001$). That is, the FIT Game increased vegetable consumption among the 55.4% of children who consumed no vegetables during baseline but did not change vegetable consumption among those children who were consuming vegetables before the game began. Thus, limited data suggest that the

FIT Game can impact healthy eating among children most in need of dietary change.

Implications for research and practice

This project reduced labor costs and disruptions of the academic routine, while increasing the implementation fidelity of the FIT Game. These changes were associated with larger increases in vegetable consumption, relative to prior implementations of the game.^{28,29} Although the FIT Game is a low-cost, low-labor intervention that can positively impact healthy eating in elementary schools, future research must address the fact that its impact is limited to times when the game is played. Increasing the duration of the game is one possible avenue to achieving lasting effects, but if this approach fails to produce long-term improvements in dietary decision making, then these programs may need to be implemented chronically if they are to impact public health. If the latter proves necessary, ensuring that these interventions are low-cost, low-labor, and easily implemented with high fidelity will remain a priority.

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Author Disclosure Statement

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