INCENTIVIZING FRUIT, VEGETABLE AND PHYSICAL ACTIVITY LEVEL CHANGE: EXPANSION AND EVALUATION OF THE FIT GAME PROGRAM FOR HEALTHY BEHAVIOR CHANGE IN ELEMENTARY SCHOOLS

by

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A dissertation submitted in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Nutrition, Dietetics and Food Science

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ABSTRACT

Incentivizing Fruit, Vegetable and Physical Activity Level Change: Expansion and Evaluation of the Fit Game Program for Healthy Behavior Change in Elementary Schools

by

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Most children do not consume the recommended amounts of fruit and vegetables (FV). The FIT Game is incentive-based intervention that targets FV consumption in elementary children during school lunch. This series of studies aimed to address the cost and labor limitations of the FIT Game (Chapter II), determine if the FIT Game could incentivize other healthy behaviors such as physical activity (PA) (Chapter III) and evaluate the ability of the FIT Game to motivate FV consumption over a longer intervention period and 3-month follow-up (Chapter IV).

In Chapter II we evaluated the ability of a lower-cost and labor-efficient version of the FIT Game to motivate FV levels in schoolchildren. Vegetable consumption was targeted in two schools, using an ABAB reversal design, with a 99.9% increase in consumption. We concluded that the cost-reduced design did not affect the FIT Game’s ability to motivate healthy eating.
Chapter III piloted a version of the FIT Game tailored to motivate PA in children. This pilot took place in one sixth grade classroom using an ABAB reversal design, with PA measured via Fitbit accelerometers. Results show the FIT Game’s capability to motivate PA, with daily step-counts increasing by 670 steps while playing the FIT Game.

In Chapter IV a longer version of the FIT Game was introduced into one elementary school, using a randomized experimental design that increased intervention days from three weeks to three months. Individual photo data and skin carotenoid scans were used to determine the effect the FIT Game had on individual FV consumption and FV intake outside of school hours. Results indicate the FIT Game was able to maintain elevated FV intakes over the course of the intervention and follow-up periods, for both group and individual data. Skin carotenoids were higher than expected, suggesting that the FIT Game may have positive effects on FV consumption outside of school lunch.

Chapter V discusses overall results from these studies, positive components of the FIT Game that contribute to its success, limitations and recommendations for future research. Conclusions regarding the use of the FIT Game for healthy behavior motivation are also made.

(179 Pages)
PUBLIC ABSTRACT

Incentivizing Fruit, Vegetable and Physical Activity Level Change: Expansion and Evaluation of the Fit Game Program for Healthy Behavior Change in Elementary Schools

Damon L. Joyner

Researchers in the Nutrition, Dietetics and Food Science department and Psychology department sought to improve healthy behaviors in elementary schools such as fruit and vegetable consumption (FV) and daily physical activity (PA). We chose to use a healthy behavior program called the “FIT Game” that has successfully increased FV consumption among elementary-aged children over short periods of time. Our aim was to improve the program by lowering operating costs, adjusting its materials to target PA and see if it could maintain healthy eating improvements over a longer period of time. Our series of research shows encouraging results: short term improvements in healthy eating using the low-cost FIT Game; improvements in PA; and maintained improvements in FV consumption over longer durations.

Improving healthy behaviors such as FV consumption and daily PA are important goals that can improve future health. Using the FIT Game intervention represents a low-cost and sustainable way to work toward these goals.
ACKNOWLEDGMENTS

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I would like to thank Dr. Heidi Wengreen for her guidance and mentorship throughout my graduate career. Her support and feedback have allowed me to learn and grow into a better researcher, student and future educator. I would also like to thank those serving on my committee, Drs. Greg Madden, Carrie Durward, Martha Archuleta and Julie Gast, along with research dietician Sheryl Aguilar, for their support and assistance throughout this process.

I also give thanks to my wife, who has been a beacon of endless support and encouragement. Her love, sacrifices and dedication have served as inspiration to me as we approach the end of this journey.

Damon L. Joyner
# CONTENTS

<table>
<thead>
<tr>
<th>ABSTRACT</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBLIC ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>x</td>
</tr>
</tbody>
</table>

## CHAPTER

I. INTRODUCTION TO THE PROBLEM AND RATIONALE FOR INVESTIGATION ............................................................ 1
   - Review of Literature ................................................................. 5
   - Factors to Consider When Motivating Behavior Change .................. 9
   - Past Programs Targeting FV Consumption .................................. 14
   - Past Programs Targeting PA ....................................................... 24
   - Factors Contributing to the FIT Game’s Effectiveness for Behavior Modification ........................................... 31
   - References ................................................................................... 35

II. THE FIT GAME III: REDUCING THE OPERATING EXPENSES OF A GAME-BASED APPROACH TO INCREASING HEALTHY EATING IN ELEMENTARY SCHOOLS .............................................. 67
   - Methods ....................................................................................... 70
   - Results ........................................................................................ 75
   - Discussion ................................................................................... 78
   - References ................................................................................... 83

III. USING THE FIT GAME TO INCREASE PHYSICAL ACTIVITY IN ONE SIXTH-GRADE CLASSROOM ...................................................................................................................... 87
   - Methods ....................................................................................... 90
   - Results ........................................................................................ 94
   - Discussion ................................................................................... 95
   - References ................................................................................... 99

IV. THE FIT GAME IV: EXPANSION AND EVALUATION OF A GAME-BASED APPROACH TO IMPROVE FV INTAKE IN SCHOOLCHILDREN ................................................................. 104
   - Methods ...................................................................................... 107
   - Results ....................................................................................... 118
   - Discussion .................................................................................. 130
   - References .................................................................................. 136
V. GENERAL DISCUSSION .................................................................143
   Project Summary .............................................................................143
   Components of the FIT Game Contributing to its Success .................146
   Limitations of the FIT Game .........................................................149
   Limitations of School-Based Interventions ....................................150
   Recommendations for the FIT Game .............................................151
   Conclusion .....................................................................................153
   References .....................................................................................155

APPENDICES ....................................................................................160
   A: Permission Letters (3) from Non-committee-member Co-authors to
      Reprint Publication as Chapters II ................................................161
   B: Permission to Reprint Publication from Games for Health Journal as
      Chapter II ..................................................................................164

CURRICULUM VITAE........................................................................165
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1 Comparison of non-objective and objective measures in school-based FV interventions</td>
<td>19</td>
</tr>
<tr>
<td>1-2 Summary of school-based interventions targeting PA in children</td>
<td>25</td>
</tr>
<tr>
<td>4-1 Baseline characteristics, by school, of individual measurements</td>
<td>119</td>
</tr>
<tr>
<td>4-2 Observed means for FV intake and carotenoid scans of treatment and control schools by phase</td>
<td>120</td>
</tr>
<tr>
<td>4-3 Model summaries for linear regression, Carotenoid Score as DV</td>
<td>125</td>
</tr>
<tr>
<td>5-1 Comparison of mean FV increases at intervention and follow-up for Food Dudes and FIT Game interventions during school lunch</td>
<td>147</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>2-1</td>
<td>FIT Game characters</td>
</tr>
<tr>
<td>2-2</td>
<td>Amounts of fruits and vegetables consumed during baseline and while playing the game by school</td>
</tr>
<tr>
<td>2-3</td>
<td>Percent of time that daily goals were met with different game elements</td>
</tr>
<tr>
<td>3-1</td>
<td>Sample slide from the FIT Game</td>
</tr>
<tr>
<td>3-2</td>
<td>Average-per-student steps taken during school hours during baseline and while playing the FIT Game</td>
</tr>
<tr>
<td>4-1</td>
<td>Estimated marginal means for individual-level, photo-estimated vegetable consumption, by phase</td>
</tr>
<tr>
<td>4-2</td>
<td>Estimated marginal means for individual-level, photo-estimated fruit consumption, by phase</td>
</tr>
<tr>
<td>4-3</td>
<td>Estimated marginal means for individual-level carotenoid scores, by phase</td>
</tr>
<tr>
<td>4-4</td>
<td>Mean group-level vegetable consumption, by phase</td>
</tr>
<tr>
<td>4-5</td>
<td>Mean group-level fruit consumption, by phase</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION TO THE PROBLEM AND RATIONALE FOR INVESTIGATION

The United States Department of Agriculture (USDA) has recognized childhood obesity as a major concern with currently more than one-third of U.S. children being overweight or obese (Ogden, Carroll, Kit, & Flegal, 2014). Children who are overweight or obese are at higher risk for developing type 2 diabetes, stroke, heart disease and cancer (National Center for Health Statistics, 2011; Office of the Surgeon General (US), 2010; Ogden et al., 2014). Consuming fruits and vegetables has been associated with a variety of health benefits including prevention of type II diabetes, some types of cancer and cardiovascular disease (Centers for Disease Control and Prevention [CDC], 2014; Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004, p. 200; Van Duyn & Pivonka, 2000). Increased physical activity (PA) has also been shown to reduce the risk of developing these diseases (Jakubowski, Faigenbaum, & Lindberg, 2015).

The USDA’s MyPlate campaign, recommend that school-aged children make a habit of consuming at least three to four half-cup servings of fruit and vegetable (FV) per day (“All about the Vegetable Group,” 2015). FV consumed should come from a variety of sources, especially those rich in color (Kim et al., 2014). Although the benefits of FV consumption are commonly known, many children do not meet these recommendations (Anderson et al., 2005; Ransley et al., 2007); this is especially true of vegetables, with less than 10% and 30% of US children consuming daily recommended levels of vegetables and fruits, respectively (Kirkpatrick, Dodd, Reedy, & Krebs-Smith, 2012).
It is recommend by the American College of Sports Medicine that children receive at least 60 minutes of moderate to vigorous PA per day (Pescatello & American College of Sports Medicine, 2014) and despite the known benefits of increasing PA (i.e. improved cardiorespiratory fitness, body composition, flexibility, and muscular strength (Office of the Surgeon General (US), 2010; Smith et al., 2014; Jakubowski et al., 2015) the majority children in the United States engage in less than 30 minutes of moderate to vigorous PA each day (Li et al., 2014; Jakubowski et al., 2015). Children who engage in more than 60 minutes of moderate and vigorous intensity PA each day receive substantial health benefits and have a better chance for a healthy adulthood (U.S. Department of Health and Human Services [USDHHS], 2008). Prominent evidence has associated increased PA with decreased adiposity in youth and increased PA in children and adolescents has also been identified as an important determinant of current and future health status (Smith et al., 2014).

Because dietary and PA habits formed during childhood are likely to carry on into adulthood (Kelder, Perry, Klepp, & Lytle, 1994; Resnicow et al., 1998; Singer, Moore, Garrahie, & Ellison, 1995; Campbell et al., 2001; Malina, 2001; Telama et al., 2005; Maynard et al., 2006) the childhood obesity epidemic may be best addressed by focusing on childhood behaviors such as increasing children’s daily energy expenditure and FV intake. Since most US children are in school for 6-8 hours a day, developing healthy lifestyle behaviors may be best accomplished during school hours, providing a stable environment where researchers could introduce behavior change interventions. School-based interventions implemented at the elementary school level have the potential to
motivate healthy behavior change because it targets early stages of pattern development and encourages lifelong patterns to continue (Webster, Monsma, & Erwin, 2010).

Children who are more physically active during the day are more likely to maintain a healthy weight, and prevent the development of chronic disease later in life (Janssen & Leblanc, 2010; “Physical Activity Facts,” 2017). Higher consumption of vegetables is associated with lower levels of body fat in male children (Field, Gillman, Rosner, Rockett, & Colditz, 2003) and children who consume diets high in fruits and vegetables may consume less energy-dense foods, contributing to a healthier energy balance (Epstein et al., 2001).

Physiologically, meeting high-intensity PA recommendations in children provides benefits such as improved metabolic markers and obesity prevention (Kang et al., 2002). Similar benefits are provided to children who meet FV daily requirements, such as an improved body composition and lower risk of obesity (Field et al., 2003). Providing a combined dietary-physical activity intervention can also lead to increased bone strength in obese children during the critical period of bone development (Nemet, Berger-Shemesh, Wolach, & Eliakim, 2006).

Although there have been several interventions targeting either FV consumption or PA, few integrate both (Mehtälä, Sääkslahti, Inkinen, & Poskiparta, 2014; Zhou, Emerson, Levine, Kihlberg, & Hull, 2014) and are often limited to FV measurements that rely on self-report or 24-hour recalls (Kelishadi et al., 2014). School-based interventions, although acutely successful at increasing daily amounts of FV and/or PA, are expensive both in material and labor costs for school districts to adapt, especially in long term implementations (Hendy, Williams, & Camise, 2005; Baranowski, Buday, Thompson, &
A school-based intervention known as the FIT Game, has successfully encouraged healthy eating behaviors in elementary aged children (Jones, Madden, & Wengreen, 2014). Briefly, the FIT Game intervention took place in the cafeteria during school lunch, where fictional sci-fi heroes (presented in comic book format on TV monitors) would encourage the children to eat more FV that day. If the children met their daily FV goal, they would be rewarded with the next episode of the heroes’ narrative, which was read by teachers the following day. These teacher-read narratives would explain to the children that their FV consumption helps the heroes overcome obstacles or capture villains (Jones, Madden, & Wengreen, 2014; Jones, Madden, Wengreen, Aguilar, & Desjardins, 2014).

Despite successfully increasing FV consumption during school hours, the FIT Game intervention is limited in its long term application and could be strengthened in the following ways: first, developing a longer lasting intervention would allow the researchers to better evaluate its long term effects on behavior change. This would require a longer narrative with additional elements to keep the children’s attention. Second, reducing the labor demands of its implementation in the schools. This would be done by altering the presentation and continuation of the narrative so that it is not dependent on teacher involvement. In the past iterations of the FIT Game, some teachers would forget to read the narrative and few complained about the daily interruption to their teacher schedules that reading the narrative would cause (Jones, et al., 2014; Jones, et al., 2014). Reducing production costs would facilitate its adaptation into schools with
limited financial resources. And third, reorganizing the game’s objectives (and possibly storyline) to allow for the integration of additional healthy behaviors, such as PA. This strengthens the impact the FIT Game has on obesity prevention, as integrated approaches are generally regarded as more effective (Driskell, Dyment, Mauriello, Castle, & Sherman, 2008; Kriemler et al., 2011; Sharma, 2011; O’Donnell, Greene, & Blissmer, 2014; Rush & Knowlden, 2015). Expanding the FIT Game with these three elements in mind could potentially lend for an increased ability to motivate healthy behavior change in elementary aged children.

The purpose of this research and dissertation is to evaluate the ability of a reduced cost/expanded FIT Game to motivate FV intake in the long-term as well to pilot its ability to influence other positive behavior changes, such as PA.

**Review of Literature**

More than one-third of U.S. children are overweight or obese (Ogden et al., 2014). Health organizations recommend that children consume two to three half cup servings of FV a day (“All about the Vegetable Group,” 2015, “All about the Vegetable Group,” 2015) and that they participate in at least 60 minutes of daily PA (U.S. Department of Health and Human Services, 2008; Pescatello & American College of Sports Medicine, 2014). The risk for developing childhood obesity is higher for children that do not meet FV (Finkelstein, Hill, & Whitaker, 2008) or PA guidelines (Ebbeling, Pawlak, & Ludwig, 2002; Sahoo et al., 2015).
Improving FV consumption habits in children has the potential to reduce the risk for obesity by possibly contributing to improvements in body composition (Field et al., 2003) and improved energy balance (Epstein et al., 2001). Each additional serving of FV consumed daily reduces the risk of all-cause adult mortality (Wang et al., 2014) and increased FV intake has been associated with the prevention of cancer, diabetes, and cardiovascular disease (Van Duyn & Pivonka, 2000; Tohill et al., 2004; CDC, 2014). Despite research demonstrating benefits of eating FV, consumption remains below the recommended levels (Rose & Richards, 2004) with fewer than 10% of US children meeting daily vegetable recommendations (Kirkpatrick et al., 2012).

Children who meet the daily PA recommendations have been shown to have increased classroom attention and behavior (Carlson et al., 2015), perform better academically (Strong et al., 2005; CDC, 2010), have a reduced risk for developing chronic disease and obesity later in life (Office of the Surgeon General (US), 2010; Gonsalves et al., 2015; Jakubowski et al., 2015) as well as improved bone density and muscle function (Strong et al., 2005; Smith et al., 2014). Increasing childhood activity levels offers future benefits as since childhood PA levels are predictive of adult PA levels (Campbell et al., 2001; Malina, 2001; Telama et al., 2005). However, most children in the US do not meet PA guidelines, with more than 75% of children failing to engage in at least 60 minute of daily PA (Dentro et al., 2014).

Despite childhood obesity being a multi-faceted problem, solutions to the epidemic rely on improving body composition, usually through the means of body fat loss. Body fat reduction can occur from a prolonged negative energy-balance, which can
result from increasing daily energy expenditure or decreasing daily caloric intake (Hill, Wyatt, & Peters, 2012).

The trend for daily movement in the US population is declining (Hamilton, Hamilton, & Zderic, 2007; Stamatakis, Hamer, & Dunstan, 2011; Hill et al., 2012) and increasing daily movement may help maintain energy balance through an increased daily energy-expenditure (Hill et al., 2012). Increased PA throughout the day has also been correlated with improved obesity risk factors in adults (Paffenbarger, 1988; Strong et al., 2005; Hamilton et al., 2007; Stamatakis et al., 2011) and a lower BMI (Paffenbarger, 1988; Nader, Bradley, & Houts, 2009). Low PA in children is associated with an increased BMI (Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003; McManus & Mellecker, 2012) and high PA in children is associated with a reduced risk for developing childhood obesity (Hills, Andersen, & Byrne, 2011). These associations suggest that chronically increasing daily PA in children could result in weight loss and obesity prevention.

FV have low energy-density and are often high in fiber, micronutrients and water; consuming more FV throughout the day can produce satiety that may decrease the consumption of calorie-dense, low-nutrient foods (Rolls, Ello-Martin, & Tohill, 2004). There is evidence that this may lead to weight loss in adults due to the nutrient dense FV replacing energy dense foods (Herman, Harrison, & Jenks, 2006; Ledikwe et al., 2006; Boeing et al., 2012) and with FV consumption being negatively correlated with BMI in adults (Newby et al., 2003). Evidence for this in children is limited, but associations do exist between higher FV intake and improved energy balance (Epstein et al., 2001) and body composition (Field et al., 2003), suggesting that chronically increasing daily FV consumption could potentially reduce daily caloric intake, resulting in weight loss.
Since the 2012 reform of the US National School Lunch Program, public schools now offer a wider variety of FV during school lunch (Food and Nutrition Service (FNS), USDA, 2012) improving the environment to encourage healthy eating (Madden, Price, & Sosa, 2017). However, despite these efforts to improve food selection during school lunch, children are only required to take either a fruit or a vegetable, and the fruit selection may be juice (Johnson, Podrabsky, Rocha, & Otten, 2016), which can contribute to low daily whole FV intake. Given the choice, most children choose fruit over vegetables (Kim et al., 2014) but vegetables are more nutrient dense than fruits and offer a different profile of nutrients, including fat soluble vitamins, that aren't found in many fruits (CDC, 2012; Johnson & Mohn, 2015). FV intake is also independently associated with healthy development of bone mass in boys (Vatanparast, Baxter-Jones, Faulkner, Bailey, & Whiting, 2005) and girls (McGartland et al., 2004; Tylavsky et al., 2004).

Long periods of inactivity have been shown to increase the risk for cardiovascular disease (Manson et al., 2002; Hamilton et al., 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009; Dunstan et al., 2010; Stamatakis et al., 2011). Prolonged bouts of sedentary behavior cause large muscle groups to become idle, which over prolonged periods will negatively impact HDL and plasma triglycerides (Bey & Hamilton, 2003; Hamilton, Hamilton, & Zderic, 2004; Zderic & Hamilton, 2006); it also under-loads bone which chronically can lead to decreases in bone mineral density (Frost, 1987; Marcus, 1996; Strong et al., 2005; Smith et al., 2014).

Merely increasing PA during the day has been shown to reduce risk of chronic disease in adults (Lee et al., 2005; Hamilton et al., 2007) and children (Sun et al., 2013).
This is due, in part, to increased activity of the glucose transporter GLUT4 when skeletal muscle contractions occur (Zisman et al., 2000). Glucose uptake into the muscle via GLUT4 activity has been shown to be similar in both high and low intensity movements (Kraniou, Cameron-Smith, & Hargreaves, 2006) suggesting that even moderate levels of PA (> 60 mins/week) are sufficient for this to occur. PA throughout a child’s day can be achieved through school recess and PE classes, after school sports teams, in-class activities and general play (Kahan & McKenzie, 2015; Nabors, Burbage, Woodson, & Swoboda, 2015).

While the benefits of increasing FV intake and PA levels are encouraging, weight loss and obesity prevention may be best addressed through a combination of improved healthy behaviors (Strong et al., 2005; Driskell et al., 2008; Sharma, 2011; Casazza et al., 2013; Rush & Knowlden, 2015). Meeting daily FV and PA requirements can lead to weight loss and maintenance, especially when practiced with other healthy behaviors (Li et al., 2014; Jakubowski et al., 2015).

Factors to Consider When Motivating Behavior Change

Even with the introduction of improved school food standards, children are still not consuming the recommended amounts of FV per day, despite small increases in intake (Keast, Fulgoni, Nicklas, & O’Neil, 2013; Kim et al., 2014); this is likely due to decreased motivation to do so. According to Ryan and Deci’s Self Determination Theory, motivation can be defined as feeling moved to do something, based on a continuum of external and internal factors (Ryan & Deci, 2000). Individuals may vary in the amount
and type of motivation they have (i.e. extrinsic or intrinsic). Extrinsic factors influencing the type of motivation can be derived from social pressures, avoidance of outcomes, or seeking tangible rewards/outcomes; intrinsic factors can be described as coming from within, being enjoyable, providing the person with a high sense of autonomy and being intellectually interesting. Achieving intrinsic motivation is ideal, however, it is difficult to reach and not possible to give. Ideally, behavior change interventions serve as a vehicle to carry the individual through a series of extrinsic factors, eventually leading to intrinsic motivation (Ryan & Deci, 2000).

Many interventions that motivate FV or PA change experience impressive short term effects but few have had lasting success. Simply promoting FV and PA knowledge is not enough; children presented only with information explaining the benefits of FV consumption may increase in knowledge but behavior change is unlikely or short lived (Blom-Hoffman & DuPaul, 2004; Perikkou, Gavieli, Kougioufa, Tzirkali, & Yannakoulia, 2013; List & Samek, 2015) with the same being true for PA (Kipping et al., 2014; Martin & Murtagh, 2017). Despite not always being accurate in predicting the targeted behavior (Baranowski, 2011; Noar & Mehrotra, 2011), interventions based on behavioral theory are more likely to elicit behavior change (Contento, Balch, & Bronner, 1995; Solmon, 2015) by supplying the appropriate information on how each variable in the design influences a particular behavior (Contento, 2008; Goodson, 2010).

A recent meta-analysis found that the use of theories in behavior modification interventions were more effective at eliciting the targeted behavior change than interventions that were not based on theory (Diep, Chen, Davies, Baranowski, & Baranowski, 2014). There was a positive correlation (although not significant) between
targeted behavior change and the use of multiple theories (Diep et al., 2014). Self-efficacy plays a pivotal role in the mechanisms that facilitate behavior change (Kreausukon, Gellert, Lippke, & Schwarzer, 2012). Perceived self-efficacy reflects optimistic self-beliefs when overcoming challenges and adopting a new behavior (Kreausukon et al., 2012) and is fundamental for healthy lifestyle behavior change (Bandura, 1994; Franko et al., 2008; Neumark-Sztainer, Wall, Perry, & Story, 2003).

Intervention designs also need to account for personality differences as well as varying levels of health status for the target population. Self-regulation and its factors (i.e. planning, self-inhibition, cognitive flexibility and habit maintenance) play a significant role in incentivizing behavior change (Allom & Mullan, 2012). Different levels of autonomy in an individual will have different effects on the likelihood of them adopting the new behavior. Those with high autonomy are likely to respond to gain-framed messaging, highlighting the positive outcomes of a certain behavior, and less likely respond to loss-framed messaging which emphasizes the negative outcomes if the behavior is not adopted (Churchill & Pavey, 2013).

Factors to consider when motivating healthy eating in children are individual’s sensory processing, taste perception, neophobia and temperament (intrinsic factors) as well as their peer modeling and family food environment, restriction or pressure to eat, prompting/rewards and the taste/energy content of the food (extrinsic factors) (Blissett & Fogel, 2013). Foods that tend to be rejected most among children include those which may have the greatest impact on later health; acceptance of new foods in children has greater success when introduced at a young age rather than later in life (Schwartz, Chabanet, Lange, Issanchou, & Nicklaus, 2011; Caton et al., 2014).
Goal setting can be an effective mechanism for children to adopt a new behavior as long as the incentivized behavior is also being practiced by parents, peers or school teachers (Kiefner-Burmeister, Hoffmann, Meers, Koball, & Musher-Eizenman, 2014; O’Donnell et al., 2014). Using goals can direct attention, effort and persistence toward the targeted behavior (Locke & Latham, 2002). Goal setting should be implemented so that the goal is challenging, yet reachable; goals that are perceived as too challenging or easy are not effective and usually do not result in behavior change (O’Donnell et al., 2014; Madden et al., 2017). When properly implemented, goals have been shown to increase children’s FV intakes (Rekhy & McConchie, 2014a) and PA levels (Hayes & Van Camp, 2015).

Children are more likely to adopt new healthy practices if the behavior has been modeled consistently by adults, peers or leadership figure (Caton et al., 2014; Kiefner-Burmeister et al., 2014). The use of modeling in intervention design has been used successfully in motivating healthy behaviors in FV consumption (Hardman, Horne, & Fergus Lowe, 2011; Hoffman et al., 2011; Rekhy & McConchie, 2014a) and PA increases (Baranowski et al., 2008; Horne, Hardman, Lowe, & Rowlands, 2009; Hardman et al., 2011). Modeling is also able to incentivize FV and PA behavior change by using cartoon and virtual characters that participate in and preach of the behavior’s benefits (Hardman et al., 2011; Horne, et al., 2009; Horne, Hardman, Lowe, & Rowlands, 2009; Hoffman et al., 2011).

Motivating healthy behavior change in children with rewards has traditionally been thought to decrease liking for the behavior. Lepper, Greene and Nisbett’s (Lepper, Greene, & Nisbett, 1973) Overjustification Theory suggests that is the promise of reward
that decreases the value of the behavior, causing the child to think: “If I have to be rewarded to do X, then I must not like it very much”. Evidence for this is mixed, with research demonstrating that using rewards to motivate behavior does not decrease liking (Wardle, Herrera, Cooke, & Gibson, 2003) as well as research showing a negative effect on the liking of the behavior when motivated with rewards (Cooke, C, et al., 2011).

Despite mixed results on a behavior’s liking, using rewards has been shown to be helpful in motivating healthy behavior change in children, although it can become costly if used for long periods of time. Tangible rewards are effective in producing short term increases in FV (D Just & Price, 2011) as well as in PA levels (Horne, Hardman, Lowe, & Rowlands, 2009; Hardman et al., 2011). Some FV research suggests that children need eight to ten exposures to a food for their preference for it to increase; tangible rewards may be effective in bringing children to that threshold (Hendy et al., 2005). Small monetary and prize rewards are effective in motivating and promoting healthy eating but are not permanent solutions, lasting only a few weeks or months before intake returns to baseline levels (Cooke, Chambers, Añez, & Wardle, 2011) and are not always monetarily feasible for low income school districts.

Non-tangible rewards such as praise or added privileges can be effective in encouraging children to taste and try new FV (Cooke et al., 2011) and increase FV consumption (Wardle et al., 2003; Blom-Hoffman, Kelleher, Power, & Leff, 2004, p.). PA has also been shown to increase when children are rewarded with social praise (Efrat et al., 2013). When compared to tangible rewards, the research is unclear on the effectiveness of non-tangible rewards—some studies indicate that they may be just as effective (Cooke et al., 2011; Jones, Madden, & Wengreen, 2014; Jones et al., 2014) and
other research suggesting that non-tangible rewards are less effective than tangible incentives (Remington, Añez, Croker, Wardle, & Cooke, 2012; Morrill, Madden, Wengreen, Fargo, & Aguilar, 2016).

**Past Programs Targeting FV Consumption**

Compliance to the updated National School Lunch Guidelines requires students to take at least one-half cup of fruit or one-half cup of vegetable (Food and Nutrition Service (FNS), USDA, 2012). School interventions have been shown to be an effective vehicle to help children increase their daily FV intake (Howerton et al., 2007; Evans, Christian, Cleghorn, Greenwood, & Cade, 2012). However, these changes are usually short term, as intrinsic barriers make it difficult to increase FV intake in children for lasting periods of time (Blissett & Fogel, 2013) and extrinsic barriers, such as material and labor costs, restrict the school’s ability to implement interventions, due to funding restrictions (Rush & Knowlden, 2015). Designing school-based interventions with low operating costs may help overcome these difficulties as well as potentially allowing the intervention to be run in schools for longer periods of time (Rush & Knowlden, 2015).

Older studies have shown strong support for the efficacy of frequent exposure to a new food, demonstrating that trying a new food more often increases the liking for it (Birch & Marlin, 1982; de Silva, 1988; Pliner, 1982; Sullivan & Birch, 1994). Even just watching a person eat healthy foods provides a form of modeling which could increase FV acceptance (Leann, Lipps, Birch, Zimmerman, & Hind, 1980; Hobden & Pliner, 1995). Despite a small sample size, Wardle et al. (2003) was able to demonstrate this
Mere Exposure Effect by simply allowing children (ages 6-8 years old) to handle and taste the new food daily which resulted in elevated FV intake. Similar findings have been seen in cafeterias by requiring placement of FV on lunch trays, exposing them to FV on a daily basis; this additional (albeit required) exposure of FV led the children to increase consumption for the intervention period (Just & Price, 2013). It should be noted, that although FV intake increased, FV waste also increased incurring elevated and unrealistic food costs to the schools (Just & Price, 2013).

Modifying the home and familial environment of every school aged child is not feasible for an intervention to undertake. Therefore, interventions may see greater effects by focusing their efforts on a school-based setting, allowing researchers to introduce interventions to a large sample of children in a relatively controlled environment (Madden et al., 2017). Education-based interventions have shown both moderate increases in FV consumption (Auld, Romaniello, Heimendinger, Hambidge, & Hambidge, 1999; Auld, Romaniello, Heimendinger, Hambridge, & Hambridge, 1998) and nonsignificant effects (Blom-Hoffman & DuPaul, 2004; Reynolds et al., 2000). However, school-based interventions with more than just FV education components are generally more successful at increasing FV than are those that promote intake solely through education of FV benefits (Blom-Hoffman et al., 2004; Perikkou et al., 2013; List & Samek, 2015).

Small modifications to the school’s environment have shown significant short term increases in FV intake, such as having recess scheduled before lunch (Getlinger, Laughlin, Bell, Akre, & Arjmandi, 1996) or by having FV options pre-sliced (where applicable) for the children to eat (McCool, Myung, & Chien, 2005). Changes to the cafeteria have also been effective, such as placing vegetables as the first option in line.
(Redden et al., 2015) and replacing the names of FV to be more exciting and fun (e.g. “X-Ray Vision Carrots”; (Wansink, Just, Payne, & Klinger, 2012). Branding healthy foods with cartoon characters is another way FV consumption has been shown to increase over short term periods (Wansink, Just, & Payne, 2012; R. M. Siegel et al., 2015; R. Siegel et al., 2016; Hanks, Just, & Brumberg, 2016; Hudgens et al., 2017). Chef prepared meals increased FV intake for one school district (made up of 14 schools), showing that improving the quality of food may be enough to motivate children to eat and try new FV (Cohen et al., 2015). However, most districts lack adequate funds to hire a long term chef.

In coordination with the Self Determination Theory, children are more likely to be intrinsically motivated to do any activity, including eating FV, if there are several choices available to them, enhancing the intrinsic nature of the decision (Ryan & Deci, 2000). When children in the cafeteria were given several FV choices for lunch, FV consumption increased when compared to consumption with only one FV option (Adams, Pelletier, Zive, & Sallis, 2005; Hendy et al., 2005); likewise, self-efficacy for FV consumption increased when schools offered FV peer modeling during lunch periods (Hendy et al., 2005).

Hoffman et al. performed a two and one-half year-long intervention based on Bandura’s Social Learning Theory (Bandura, 1994) in elementary schools consisting of daily loudspeaker announcements, classroom DVD time, take home activity books and receipt of a sticker contingent on a bite of FV (Hoffman et al., 2011). The intervention fulfilled Social Learning Theory’s requirement of influential role models (peers in videos, cartoon characters, teachers) delivering consistent information regarding FV (Hoffman et
Other interventions incentivizing FV consumption solely through the use of small rewards have seen similar increases in consumption (Remington et al., 2012; Loewenstein, Price, & Volpp, 2016).

The “Food Dudes” intervention was introduced in the United Kingdom basing using role modeling, rewards and repeated exposure/tastings of novel FV (Horne et al., 2004; Horne, Hardman, Lowe, Tapper, et al., 2009; Lowe, Horne, Tapper, Bowdery, & Egerton, 2004). The “Food Dudes” characters are four children, two boys and two girls, who present positive messages about FV consumption and encourage the children to eat more FV like they do. When the children eat the incentive FV, they received stickers. Food Dudes interventions have shown significant short term increases in FV consumption (Horne et al., 2004; Horne, Hardman, Lowe, Tapper, et al., 2009; Lowe et al., 2004) although a longer implementation did not produce such effects, warranting modifications to increase longevity (Upton, Upton, & Taylor, 2013).

The “Food Dudes” intervention has been replicated in the United States producing similar results, especially among children who began with low FV intakes (Wengreen, Madden, Aguilar, Smits, & Jones, 2013). The “FIT Game” was later introduced by the same group of U.S. researchers improving character design/presentation and storyline while maintaining many of the successful aspects of the “Food Dudes” program (role modeling, rewards, repeated tasting, and plate waste measures). In two recent publications, the “FIT Game” showed significant short term increases in FV consumption in school-aged children (Jones, Madden, & Wengreen, 2014; Jones et al., 2014).

While objectively measured FV intake is ideal for determining consumption in children (Buzby & Gunthrie, 2002), few studies incorporate its use, relying on visual
estimates or self-reported food consumption (sometimes assisted by parents) to determine consumption, which are prone to bias (Comstock, Symington, Chmielinski, & McGuire, 1979) and to subject to systematic reporting errors (Schoeller et al., 2013). The Hawthorne effect (McCarney et al., 2007) likely contributes to these errors, meaning that when participants are evaluated on FV decisions, they may be more likely to report higher FV intakes due to their belief that this is favorable to the researchers.

For FV measures, objective measurements most frequently involve a form of plate waste measurement: physically weighing food before and after a meal to determine consumption. Many researchers estimate consumption visually or by recording the amount served; while this may provide useful information, it is not an objective form of FV consumption. Studies that objectively measure FV intake reduce bias and stand out from other FV interventions who are reliant on subjective reporting; the “Food Dudes” and “FIT Game” interventions both measure FV consumption via objective FV plate waste (Horne et al., 2004; Lowe et al., 2004; Horne, Hardman, Lowe, Tapper, et al., 2009; Jones, Madden, & Wengreen, 2014; Jones et al., 2014). For a comparison of non-objective and objective measures in school-based FV interventions, see Table 1-1.

For the past decade, a diversity of interventions designed to motivate and increase FV consumption have been introduced. These interventions are more successful when they include factors such as: having behavior change (not FV serving sizes) as the target goal, using clear messages, modeling the behavior and having interventions that last more than a few weeks. However, the impact of these interventions are at best, moderate to low, with chronically sustaining increased FV intake being the most cited difficulty (Rekhy & McConchie, 2014).
Table 1-1: Comparison of non-objective and objective measures in school-based FV interventions

<table>
<thead>
<tr>
<th>Study Ref.</th>
<th>Methods</th>
<th>FV Measure</th>
<th>Incentives</th>
<th>Results</th>
<th>Follow-up?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auld et al. 1998</td>
<td>FV education</td>
<td>Visual estimates</td>
<td>NA</td>
<td>FV: +46%</td>
<td>No</td>
</tr>
<tr>
<td>Auld et al. 1999</td>
<td>FV education</td>
<td>Visual estimates</td>
<td>NA</td>
<td>FV: +46%</td>
<td>No</td>
</tr>
<tr>
<td>Reynolds et al. 2000</td>
<td>FV education</td>
<td>Visual estimates</td>
<td>NA</td>
<td>FV: NS</td>
<td>1-Year; FV: NS</td>
</tr>
<tr>
<td>Blom-Hoffman et al. 2004</td>
<td>Education, modeling, incentives</td>
<td>Visual estimates</td>
<td>Praise &amp; stickers</td>
<td>V: (exp group) NS (waitlist control) +43%</td>
<td>7-month; FV: NS</td>
</tr>
<tr>
<td>Study</td>
<td>Setting</td>
<td>Methodology</td>
<td>Intervention</td>
<td>F:</td>
<td>V:</td>
</tr>
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</tr>
<tr>
<td>Horne et al. 2004</td>
<td>Food Dudes</td>
<td>Visual estimates</td>
<td>Small prizes</td>
<td>+131-151%</td>
<td>+93-161%</td>
</tr>
<tr>
<td>Lowe et al. 2004</td>
<td>Food Dudes</td>
<td>Visual estimates; Plate waste</td>
<td>Small prizes</td>
<td>+50-75%</td>
<td>+91-137%</td>
</tr>
<tr>
<td>Hendy et al. 2005</td>
<td>Choice, incentives, peer</td>
<td>Visual estimates</td>
<td>Tokens for prizes</td>
<td>+36%</td>
<td>+51%</td>
</tr>
<tr>
<td>Hoffman et al. 2011</td>
<td>Modeling, education, incentives</td>
<td>Visual estimates</td>
<td>Stickers</td>
<td>(Yr1) +50% (Yr2)</td>
<td>+39% (Yr3)</td>
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<tr>
<td>Wansink et al. 2012a</td>
<td>Attractive FV naming</td>
<td>Amount served</td>
<td>NA</td>
<td>+50%</td>
<td></td>
</tr>
<tr>
<td>Just &amp; Price 2013</td>
<td>Default provision &amp; incentives</td>
<td>Visual estimates</td>
<td>Small prizes, money</td>
<td>+48-60%</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Default provision</td>
<td>Visual estimates</td>
<td>Study 1: small prizes</td>
<td>Combined: FV not affected with required FV</td>
<td>F: +27-35%</td>
</tr>
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<tr>
<td>Just &amp; Price 2013</td>
<td>Default provision</td>
<td>Visual estimates</td>
<td>Study 1: small prizes</td>
<td>Combined: FV not affected with required FV</td>
<td>No</td>
</tr>
<tr>
<td>Wengreen et al. 2013</td>
<td>Food Dudes</td>
<td>Photo estimates</td>
<td>Small prizes</td>
<td>F: +27-35%</td>
<td>No</td>
</tr>
<tr>
<td>Redden et al. 2015</td>
<td>V served first in isolation</td>
<td>Amount served</td>
<td>NA</td>
<td>Carrot: +430%</td>
<td>No</td>
</tr>
<tr>
<td>Siegal et al. 2015</td>
<td>Branding vegetables</td>
<td>Amount served</td>
<td>NA</td>
<td>V: +29%</td>
<td>No</td>
</tr>
<tr>
<td>Hanks et al. 2016</td>
<td>Branding, education</td>
<td>Amount served</td>
<td>NA</td>
<td>FV: +134%</td>
<td>No</td>
</tr>
<tr>
<td>Loewenstein et al. 2016</td>
<td>Incentives</td>
<td>Visual estimates</td>
<td>Small prizes</td>
<td>FV: +21- 44%</td>
<td>No</td>
</tr>
<tr>
<td>Study</td>
<td>Intervention</td>
<td>Measure</td>
<td>Condition</td>
<td>Result 1</td>
<td>Result 2</td>
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<tr>
<td>Morrill et al. 2016</td>
<td>Food Dudes</td>
<td>Photo estimates</td>
<td>Small prizes</td>
<td>FV: (prize) +46-92% (praise) +46-50%</td>
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<tr>
<td>Siegal et al. 2016</td>
<td>Social norm messages</td>
<td>Amount served</td>
<td>NA</td>
<td>FV: (study 1) +30-50% (study 2) NS</td>
<td>No</td>
</tr>
<tr>
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<tr>
<td>Objective Measures</td>
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</tr>
<tr>
<td>Adams et al. 2005</td>
<td>Salad bars</td>
<td>Plate waste</td>
<td>NA</td>
<td>FV: NS</td>
<td>No</td>
</tr>
<tr>
<td></td>
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<tr>
<td>McCool et al. 2005</td>
<td>Whole vs sliced apples</td>
<td>Plate waste</td>
<td>NA</td>
<td>F: +47% sliced (alone)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>F: +87% sliced (offered with whole)</td>
<td></td>
</tr>
<tr>
<td>Getlinger et al. 2006</td>
<td>Recess before vs. after lunch</td>
<td>Plate waste</td>
<td>NA</td>
<td>F: -6% (recess before)</td>
<td>No</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>V: +46% (Recess after)</td>
<td></td>
</tr>
<tr>
<td>Horne et al.</td>
<td>Food Dudes</td>
<td>Plate waste</td>
<td>Small prizes</td>
<td>F: +61% V +120%</td>
<td>12-month;</td>
</tr>
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</tr>
<tr>
<td>Year</td>
<td>Study Authors</td>
<td>Intervention Details</td>
<td>Waste Type</td>
<td>Result</td>
<td>Additional Details</td>
</tr>
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</tr>
<tr>
<td>2009</td>
<td>Upton et al.</td>
<td>Default provision</td>
<td>Plate waste</td>
<td>NA</td>
<td>FV: +41%</td>
</tr>
<tr>
<td>2012</td>
<td>Upton et al.</td>
<td>Food Dudes</td>
<td>Plate waste</td>
<td>Small prizes</td>
<td>FV: +14%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12-month; FV: -10%</td>
</tr>
<tr>
<td>2013</td>
<td>Jones et al.</td>
<td>FIT Game</td>
<td>Plate waste</td>
<td>Virtual rewards</td>
<td>F: +66%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V: +44%</td>
</tr>
<tr>
<td>2014</td>
<td>Jones et al.</td>
<td>FIT Game</td>
<td>Plate waste</td>
<td>Virtual rewards</td>
<td>F: 39%</td>
</tr>
<tr>
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<td></td>
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<td></td>
<td></td>
<td>V: +33%</td>
</tr>
<tr>
<td>2015</td>
<td>Cohen et al.</td>
<td>Chef prepared meals</td>
<td>Plate waste</td>
<td>NA</td>
<td>FV: +25-31%</td>
</tr>
<tr>
<td>2017</td>
<td>Hudgens et al.</td>
<td>Branding, incentives</td>
<td>Plate waste</td>
<td>Small prizes</td>
<td>FV: +71%</td>
</tr>
</tbody>
</table>

*FV: Fruit/vegetable consumed
b %: reported as FV percent increases from baseline or control
* NS: Non-significant
Past Programs Targeting PA

School-based interventions have been shown to elevate PA levels by as much as 45 minutes a day, with children who are exposed to the intervention being three times more likely to engage in PA in a setting outside of school (Dobbins, Husson, DeCorby, & LaRocca, 2013). Research also indicates that school-based interventions may be more effective if introduced at an earlier age, with adolescent children being less receptive to PA change than elementary children (Nader et al., 2009; Dobbins et al., 2013). PA interventions are more likely to be successful if they are based on behavior theories, use a multicomponent design (Kriemler et al., 2011; Lai et al., 2014) and incorporate strategies for progression (Baranowski et al., 2008; Hayes & Van Camp, 2015). As is the case in motivating FV consumption, maintaining elevated PA levels is difficult to maintain in the long term; most PA interventions show short term effects (Kriemler et al., 2011; Dobbins et al., 2013; Berger et al., 2014). Table 1-2 provides a summary of school-based interventions targeting PA in children.

Policy changes, such as increasing the frequency of PE classes throughout the week, have seen mild increases in PA levels; however, the challenges of implementing and monitoring district policies make this a difficult option (Kahan & McKenzie, 2015; Reznik, Wylie-Rosett, Kim, & Ozuah, 2015) and may not be financially possible for most districts (Babey, Wu, & Cohen, 2014). Attempts to increase PA solely through educational courses (i.e. providing information regarding the benefits of PA, how to properly execute a movement and strategies to increase daily activity) have been ineffective at significantly increasing PA levels in children (Kipping et al., 2014; Martin & Murtagh, 2017; Solmon, 2015).
<table>
<thead>
<tr>
<th>Study Ref.</th>
<th>Methods</th>
<th>PA Measure</th>
<th>Incentives</th>
<th>Results</th>
<th>Follow-up?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horne et al. 2009</td>
<td>Modified Food Dudes</td>
<td>Pedometer</td>
<td>Small prizes</td>
<td>PA $^a$: (girls) +37% $^b$ (boys) +27%</td>
<td>12-week; PA: (girls) +27% (boys) +11%</td>
</tr>
<tr>
<td>Hardman et al. 2011</td>
<td>Modified Food Dudes</td>
<td>Pedometer</td>
<td>Small prizes</td>
<td>PA: (full) +5-21%</td>
<td>8 days; PA: +1-15%</td>
</tr>
<tr>
<td>Nicaise et al. 2012</td>
<td>Playground modification</td>
<td>Accelerometer, visual estimates</td>
<td>NA</td>
<td>PA: +12-15%</td>
<td>No</td>
</tr>
<tr>
<td>Efrat et al. 2013</td>
<td>Prompting, modeling</td>
<td>Accelerometers</td>
<td>NA</td>
<td>PA: (prompt) +44% (model) NS</td>
<td>No</td>
</tr>
<tr>
<td>Engelen et al. 2013</td>
<td>Education, playground modifications</td>
<td>Accelerometer</td>
<td>NA</td>
<td>PA: +4%</td>
<td>24-month; PA: NS $^c$</td>
</tr>
<tr>
<td>Study</td>
<td>Intervention</td>
<td>Measurement</td>
<td>PA:</td>
<td>No/Loss</td>
<td></td>
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</tr>
<tr>
<td>Chin et al. 2014</td>
<td>Recess games</td>
<td>Visual estimates</td>
<td>NA</td>
<td>+52%</td>
<td></td>
</tr>
<tr>
<td>Hyndman et al. 2014</td>
<td>Playground modification</td>
<td>Pedometer, visual estimates</td>
<td>NA</td>
<td>+14%</td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td>8-month;</td>
<td></td>
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<td></td>
<td></td>
<td>PA: +6%</td>
<td></td>
</tr>
<tr>
<td>Kipping et al. 2014</td>
<td>Education</td>
<td>Accelerometer</td>
<td>NA</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Hayes et al. 2015</td>
<td>Goals, praise</td>
<td>Accelerometer</td>
<td>Praise</td>
<td>+47%</td>
<td></td>
</tr>
<tr>
<td>Janssen et al. 2015</td>
<td>Playground modification, prompts</td>
<td>Accelerometer</td>
<td>NA</td>
<td>+38%</td>
<td></td>
</tr>
<tr>
<td>Riley et al. 2015</td>
<td>PA class integration</td>
<td>Accelerometer</td>
<td>NA</td>
<td>+9-10%</td>
<td></td>
</tr>
<tr>
<td>Tymms et al. 2015</td>
<td>PA class integration</td>
<td>Accelerometer</td>
<td>NA</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Beets et al. 2015</td>
<td>PA class integration</td>
<td>Accelerometer</td>
<td>NA</td>
<td>+2-11%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24-month;</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Study</td>
<td>Intervention</td>
<td>Device</td>
<td>Baseline</td>
<td>PA:</td>
</tr>
<tr>
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</tr>
<tr>
<td>2016</td>
<td>Sutherland et al.</td>
<td>PA class integration</td>
<td>Accelerometer</td>
<td>NA</td>
<td><strong>PA:</strong> +14%</td>
</tr>
<tr>
<td>2017</td>
<td>Martin et al.</td>
<td>Education</td>
<td>Accelerometer</td>
<td>NA</td>
<td><strong>PA:</strong> NS</td>
</tr>
</tbody>
</table>

*aPA: Daily physical activity levels recorded  
b%: reported as percent increases in PA from baseline or control  
cNS: Non-significant*
Simple playground modifications have been successful at increasing PA levels. Such interventions include designating areas on the playground where children are only allowed to run and jog (Black, Menzel, & Bungum, 2015) as well as supplying children with loose playground equipment that encourage co-operation and gross motor development (Engelen et al., 2013; Hyndman, Benson, Ullah, & Telford, 2014; M. Janssen, Twisk, Toussaint, van Mechelen, & Verhagen, 2015; Nicaise, Kahan, Reuben, & Sallis, 2012). Playgrounds that have more structures or markings for games have been shown to encourage higher levels of recess activity (McKenzie, Crespo, Baquero, & Elder, 2010; Nicaise et al., 2012; Escalante, García-Hermoso, Backx, & Saavedra, 2014).

Setting PA goals at recess has also been effective at increasing PA (Hayes & Van Camp, 2015) as has having teachers prompting children to move more while at recess (Efrat, 2013; Chin & Ludwig, 2014; M. Janssen et al., 2015). Short ten minute breaks of vigorous PA during regular class periods proved to be a significantly effective way of increasing PA and maintaining classroom attention (Babey et al., 2014; Carlson et al., 2015). Some programs have furthered this idea by integrating PA principles during curriculum lessons throughout the day (Beets et al., 2015; Riley, Lubans, Morgan, & Young, 2015; Sutherland et al., 2016; Tymms et al., 2016). While the increased PA from lesson and classroom integration is encouraging, it should be noted that these increases were measured in class-time PA and not daily PA.

Using game-based principles to increase PA may help maintain interest and increase motivation (Squire & Jenkins, 2003; Sit, Lam, & McKenzie, 2010a, 2010b; Sherry, Lucas, Greenberg, & Holmstrom, 2013). Several game-based approaches utilizing computer or video technology to increase PA have been undertaken with
moderate successes (Baranowski et al., 2008; Kamel Boulos, 2012; Osorio, Moffat, & Sykes, 2012; Miller, Vaux-Bjerke, McDonnell, & DiPietro, 2013). A shortcoming of using a video game platform is progression in the game does not require objectively measured/verified PA to advance the game, which could lead to false reports of PA or decreased motivation to participate.

While none have been published to date, non-video game PA interventions using a game-based design offer potential advantages over their video-game counterparts such as a reward system that is built into the game (i.e. non-tangible) and requiring little to no computer/video hardware to operate. As seen in the FV-targeting FIT Game, non-video game interventions using game-based models can serve as a low cost option to motivate healthy behaviors (Jones, Madden, & Wengreen, 2014; Jones et al., 2014; Morrill et al., 2016) offering the benefits of tangible rewards without causing financial burden for schools. Non-tangible reward use has shown increases in behavior that are comparable to interventions that use tangible reward systems (Morrill et al., 2016).

Interventions need to be appropriately marketable to children, creating a challenge to develop material that is sufficiently engaging for older children while still enabling younger children to comprehend (Jago et al., 2015). Attention should be given to ensure presentation of information that is applicable and interesting to both genders (Kelishadi et al., 2014; Marandi et al., 2014). Programs need to be sufficiently challenging to meet physical thresholds without becoming too difficult, risking decreases in motivation (Jakubowski et al., 2015).

Measuring PA in children via self-report is prone to error and loss of potentially meaningful data (Nabors et al., 2015) and has a low correlation when compared to
Objectively measured PA (Wallace, Mckenize, & Nader, 2013). Obtaining objective measures of PA in children provides many barriers to researchers such as the financial costs of purchasing calibrated equipment for each child, technological difficulties associated with using the equipment with children in classroom settings and data reporting errors due to biases among varying equipment types (Loprinzi & Cardinal, 2011; Van Camp & Hayes, 2012). Among the available devices used to measure PA in children, pedometers and wrist-worn accelerometers are currently the most feasible for researchers to implement into school-based interventions due to their simplicity, objective measures and non-invasiveness (Loprinzi & Cardinal, 2011).

Pedometers are an inexpensive and simple tool for measuring PA, however, limitations include children losing pedometers, forgetting to attach the device to their waist and manipulated step counts from shaking the device (Loprinzi & Cardinal, 2011; Van Camp & Hayes, 2012). Despite pedometers providing users with step-count estimations, they are prone to inaccuracies, and lack the ability to capture movement intensity (Le Masurier & Tudor-Locke, 2003; Tudor-Locke & Lutes, 2009). Consumer grade accelerometers (such as the Fitbit Flex) offer several advantages over pedometers such as the capability to detect lateral and vertical movements (pedometers only capture vertical movements), measure movement intensity (Bassett & John, 2010) and the use of algorithms to prevent against step miscounts (Evenson, Goto, & Furberg, 2015).
Factors Contributing to the FIT Game’s Effectiveness for Behavior Modification

The FIT Game remains a viable program for motivating healthy behavior change in elementary-aged children in school setting. It uses several factors that have been identified in successful interventions such as rewards, role models, repeated-exposure, progressive goal-setting and game-based elements (Jones et al., 2014). When a school plays the FIT Game, they are introduced to four sci-fi characters (the FITs) whose mission it is to save the universe from the evil Vegetation Annihilation Team (VAT). The object of the game is to help the FITs locate and eventually capture all members of the VAT before planetary destruction occurs.

Events within the narrative are dictated by the school’s ability to meet daily healthy eating goals. By meeting daily goals, the school influences the storyline by helping the heroes compete against virtual opponents, and earn virtual currency. Each day’s FIT Game episode is presented as comic-book format via posters or TV screens, in a central location in the school’s cafeteria. Daily FV consumption levels are determined using objective plate waste measurements and photo estimations.

Throughout the game’s duration, daily FV consumption goals are to consume at or above the 60th percentile for the previous 10 days of FV intake (Galbicka, 1994). Thus, as consumption changes, so does the goal, allowing the goal to remain challenging but attainable. This is especially true when schools consistently meet (or don’t meet daily goals) creating a difficulty level that is specifically tailored to the school. Children are not aware of the goal’s numeric value or how it is calculated but are simply encouraged to eat a little more than usual.
The FIT Game is not a video game but incorporates design-principles used in video games to motivate healthy behaviors and maintain interest in the game (Baranowski et al., 2008; Hamari, Koivisto, & Sarsa, 2014). Such principles include a clearly defined game objective, in-game currency, compelling storyline and player autonomy (Adams, 2009; Reeves & Read, 2009). As the school meets daily goals, they will complete the FIT Game’s missions, unlocking daily rewards in the form of: continuation of the narrative for the following day, the opportunity to vote on which course of action the Fits should take and using in-game currency for in-game upgrades, powering various mechanical components, unlock doors, etc. These in-game, non-tangible rewards are delivered at the group-level and are based on group-level FV consumption. The children’s real-world behaviors positively or negatively affect the progression and events within the game. Thus, the FIT Game motivates behavior by linking real-world behaviors (i.e. FV consumption) to outcomes within the game.

Each of the FIT Game character serves as a model with which the children can associate healthy behaviors. Throughout various episodes of the narrative, the children are prompted by the characters with messages encouraging them to “eat one more bite than normal of their vegetables” or to “try a bit of a vegetable that you’ve never tasted before”. These frequent prompts aide in the frequent exposure to new foods, which is estimated to take eight to ten exposures before a child will try it (Hendy et al., 2005). This repeated exposure to new food is one of the reasons cited for the Food Dudes intervention’s elevated FV intake (Horne et al., 2004; Lowe et al., 2004; Horne, Hardman, Lowe, Tapper, et al., 2009) and could be influential in creating healthy habits
over long terms, especially since some evidence suggests that health behavior change can take ten weeks before a habit is formed (Lally, van Jaarsveld, Potts, & Wardle, 2010).

In-game rewards (extrinsic) that children earn throughout the game may serve as a vehicle for maintaining the behavior of continuing to eat or trying new FV options. As children try new FV during the FIT Game they have repeated opportunities to discover possible FV that they like. The FIT Game could increase self-efficacy by providing influential role models (in this case, the FITs) who model healthy eating and encourage optimistic self-beliefs concerning trying FV. These factors could increase self-efficacy for trying new things and a possibly increase intrinsic motivation to continue eating these foods after the game ends.

The purpose of this dissertation research is to: (1) evaluate the effect of an expanded/low cost FIT Game intervention on modifying FV consumption, (2) determine if the FIT Game can produce lasting FV changes over longer durations and (3) rate the FIT Game’s effectiveness for motivating PA behaviors in elementary aged children. The proposed research has three objectives:

First, a pilot intervention will evaluate the ability of an expanded FIT Game (low cost, low labor) to motivate fruit/vegetable intake at the school-wide and average-per-student levels. Chapter II summarizes the findings of this lower-cost/lower-labor version of the FIT Game.

Second, a pilot study will evaluate a modified-for-PA version of the FIT Game and its ability to motivate PA levels during school hours. Its effectiveness will be
determined by increases in PA at the classroom and average-per-student levels.

Chapter III summarizes the results for the modified-for-PA FIT Game.

Third, a longer and expanded version of the FIT Game will be implemented, evaluating its ability to increase FV intake over longer periods of time and whether its presence creates lasting effects for elevated FV consumption. FV intake will be measured at school-wide, average-per-student and individual levels during baseline, intervention and follow-up periods. Chapter IV summarizes the results for the expanded FIT Game intervention.

Chapter V collectively discusses the results of Chapters II-IV, evaluating the effectiveness of the FIT Game in reaching each of the three objectives. This chapter also discusses the components of the FIT Game that continue to produce behavior change, the limitations of the FIT Game, whether the FIT Game is suited to be an integrated behavior change model as well as recommendations and suggestions for future research.
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CHAPTER II

THE FIT GAME III: REDUCING OPERATING EXPENSES OF A GAME-BASED APPROACH TO INCREASING HEALTHY EATING IN ELEMENTARY SCHOOLS

Health organizations recommend that school-aged children consume at least 2-3 cups of FV per day\(^1\) because (a) each additional serving of fruits and vegetables (FV) consumed daily is associated with a 5% reduction in all-cause adult mortality;\(^2\) (b) consuming FV is associated with prevention of cancer, diabetes, and cardiovascular disease;\(^3-5\) (c) consuming more and a wider variety of vegetables is associated with lower levels of body fat in male children,\(^6\) and (d) children’s dietary habits carry on into adulthood.\(^7-10\) Although the benefits of FV consumption are commonly known, the majority of US children do not adhere to these recommendations;\(^11\) this is particularly true of vegetables, with fewer than 10% of US children consuming recommended levels of vegetables each day.\(^12\)

Since the 2012 reform of the US National School Lunch Program, a 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

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

Games offer a potentially inexpensive medium in which to encourage healthy eating. Much of the game-based research targeting healthy eating uses videogame platforms. 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% and 56.5%; these increases are comparable to interventions using tangible incentives. This game-based intervention, known as the FIT Game, employs several game-design elements. 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 which revealed how the school's healthy eating helped the heroes overcome an obstacle, capture a villain, earn virtual currency, etc. 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).\textsuperscript{28,29}

The present study was conducted to evaluate the efficacy of a more labor-efficient, less disruptive, and fool-proof 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 the present 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 children\textsuperscript{31} and vegetable consumption is less likely than fruit consumption to change in the face of healthy-eating interventions.\textsuperscript{32} We hypothesized that presenting the FIT Game materials in the cafeteria would significantly increase vegetable consumption.
METHODS

Participants

Schoolchildren in Kindergarten through 5th 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 x 69 cm. In the second school (School I), the episodes were presented as images projected onto a screen (approximately 4 m x 4 m) in the cafeteria.

A scale with a resolution of 1 gm (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 x 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.\textsuperscript{28,29} Prior to 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:

\[
\text{Consumption} = \frac{P_V - U_V - W_V}{N}
\]  

(Equation 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.\textsuperscript{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 (a) the occasional combination of multiple poster episodes displayed in School P into a single projected-image episode in School I, and (b) decreasing the duration of the inter-school competition (see below) in School I. Phase I began by introducing children to the fictional heroes of the game (the FITs; top panel of Figure 2-1) and the object of the FIT Game: to help the FITs capture the leaders of the Vegetation Annihilation Team (VAT; bottom panel of Figure 2-1). 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 (see below), 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. 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
Figure 2-1: FIT Game Characters
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 grams of vegetables and the average student consumed 33 grams, then 2 FIT Points were added to the display.

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 vs. 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 post-competition portion of Phase I; i.e., 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 if consumption during the FIT Game phases differed significantly from the preceding baseline phase. The SMA is appropriate for short time-series data because it considers autocorrelation, whereas repeated-measures ANOVA does not. 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, 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 2-2 shows the between-school average (± 1 SEM) grams of FV consumed per child. During Baseline I, children consumed an average of 57.6 grams of fruit (leftmost open bar in the fruit section of Figure 2-2) and 21.7 grams of vegetables (leftmost open bar in the vegetables section). In neither school was there an increasing trend in fruit ($p$’s > .26) or vegetable ($p$’s > .14) consumption over Baseline I; indeed, the
slopes were non-significantly 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 grams per child per day (leftmost filled bar in the vegetables section of Figure 2-2). Vegetable consumption increased significantly 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, non-significantly increased to an average of 74.9 grams 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 Figure 2-2), 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 grams 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 grams. While this increase approached significance in School P ($R = 0.75, p = 0.06$) it was non-significant in School I ($p = 0.77$).

Figure 2-3 shows the percentage of days on which the school met its vegetable-eating 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 values in Figure 2-3. The lowest percentage of goals met occurred during the competition at the beginning of Phase I (66.7%), which was not significantly different from chance.
Figure 2-2: Amounts of fruits and vegetables consumed during baseline and while playing the game by school (n=2).

Figure 2-3: Percent of the time that daily goals were met with different game elements in play (n=2).
Combining the good vs. 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 chances levels, this may be 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. When this specificity of the treatment effect is combined with large increases above no-intervention baseline levels, there is 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, so 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 the present 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 increased vegetable consumption.

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 behavior\textsuperscript{38}). 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{15,21,40-46} Instead, six of these studies report positive effects on consumption at follow-up assessments.\textsuperscript{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.

Regarding philosophical objections to the use of incentives (e.g., that they amount to bribes), our experience implementing tangible-incentive based interventions\textsuperscript{21,22} and 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\textsuperscript{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.\textsuperscript{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 (a) the lack of a lasting impact on FV consumption after the intervention is withdrawn, (b) the brief duration of the intervention, and (c) 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.\textsuperscript{47,48}

Longer-duration incentive-based interventions like Food Dudes have increased FV consumption 6 and 12 months after the intervention concludes.\textsuperscript{17,21} 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.\textsuperscript{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.\textsuperscript{21} On the two days in which the FIT Game targeted vegetable consumption, the ANOVA revealed a significant phase x baseline-consumption interaction ($F_{(1,155)} = 17.89$, $p < .001$). 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.\textsuperscript{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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CHAPTER III
USING THE FIT GAME TO INCREASE PHYSICAL ACTIVITY IN ONE SIXTH-GRADE CLASSROOM

Obesity is on the rise and affecting more than one-third of the childhood population (Ogden et al., 2014). Childhood obesity has negative health consequences both during childhood (Ebbeling et al., 2002; Sahoo et al., 2015) and throughout the lifespan if not ameliorated (Dietz, 1998; Reilly et al., 2003). Meeting the recommended guidelines for daily physical activity (PA) has been shown to reduce the risk for overweightness, obesity, and development of chronic disease (Jakubowski, Faigenbaum & Lindberg, 2015; Surgeon General, 2010). Increased activity also improves cardiorespiratory fitness, flexibility, and muscular strength (Smith et al., 2014) and these benefits extend into adulthood because childhood PA levels are predictive of adult PA levels (Campbell et al., 2001; Malina, 2001; Telama et al., 2005). Despite these short- and long-term benefits, many children in the United States do not meet the recommended 60 minutes of daily moderate to vigorous PA (Jakubowski, Faigenbaum & Lindberg, 2015; Li et al., 2014; Pescatello & ACSM, 2014).

Addressing this public health crisis should include school-based interventions because most children in the United States spend 6-8 hours in school, five days a week. As such, effective school-based interventions have the potential to help children develop healthy PA patterns that become habitual (i.e., consistent, daily initiation of PA without having to remember to do so (Lally et al., 2010). Within the public-school setting, the ideal intervention will positively influence healthy behavior at minimal financial and labor costs. That is, public school budgets often have few discretionary categories which
might be used to pay for healthy-behavior interventions, and school personnel have little discretionary time that may be allocated to implementing and evaluating the efficacy of these programs.

With these goals and constraints in mind, our research group developed the FIT Game, a low-cost game-based intervention designed to increase fruit and vegetable intake in elementary-aged children (Jones et al., 2014a; 2014b; Joyner et al., 2017). This low-tech intervention employs video-game design principles such as an in-game currency, player autonomy and an engaging fictional narrative in which players help the game’s heroes stop a group of villains. Within this narrative, virtual incentives (e.g., equipment needed to achieve subtasks in service of game objectives) are earned when children eat more fruits and vegetables at school. Increases in healthy eating produced by the FIT Game are comparable to those obtained when tangible rewards are provided contingent on fruit and vegetable consumption (Morrill et al, 2015).

Continuation of the narrative is dependent on the children working together to reach daily goals for the targeted behavior. When these goals are met, the children earn virtual currency that can be used to purchase in-game “power-ups” allowing characters within the game to gain special powers or abilities. In previous versions of the FIT Game, the choice of the “power-up” was determined through a popular vote in the cafeteria, where children indicated their preference for one of three “power-up” options. Past versions of the FIT Game increased the children’s fruit and vegetable intake by 61.5% (Jones et al., 2014a) and 56.5% (Jones et al., 2014b). A more recent implementation of the FIT Game evaluated whether a low-cost/low-labor version where the narrative was shared with children in a digital format in the cafeteria would still be able to motivate
healthy eating (Joyner et al., 2017). These labor and cost reductions to the FIT Game did not reduce its impact on healthy eating, with average group-level vegetable intakes increasing by 99% (Joyner et al., 2017).

While the benefits of increasing FV intake are encouraging, obesity prevention may be best addressed through a combination of healthy behaviors (Casazza et al., 2013; Driskell et al., 2008; Rush & Knowlden, 2015; Sharma, 2011; Strong et al., 2005). In an attempt to broaden the ability of the FIT Game, we piloted the FIT Game to target the behavior of being more physically active at school (unpublished data). In this small pilot the game was introduced into two 4th grade classrooms. Fitbit Flex accelerometers were given to participating children and were used to measure each student’s daily PA, measured via daily step counts. While the game was well received, technological issues with the Fitbits and Fitbit server yielded data that was unusable due to large amounts of missing data in baseline and intervention phases. The data from this small pilot should be interpreted with caution due to an average 43% of participants having missing data, however, analyses of these data, while not directly interpretable, show an average increase of 1,120 steps across all phases, suggesting the FIT Game may be able to produce significant increases in PA levels.

The purpose of the present pilot study was twofold. First, we sought to repeat the pilot study using the FIT Game to target PA at the classroom level with a plan in place to improve the data capturing method that was problematic in the first unpublished pilot study. Second, we replaced the teacher-read narratives with short PowerPoint presentations that depicted the game’s storyline and progress toward daily goals. As in Joyner et al.’s (2017) version of the FIT Game, this change to the original PA pilot was
made to lower the cost of implementation. We hypothesized that adapting the FIT Game to target childhood PA levels would significantly increase daily classroom step counts during intervention periods.

METHODS

Participants

School children from one sixth grade classroom in an elementary school located in Cache County, UT were invited to participate in this study using an active consent procedure. All 30 students and their parents/guardians consented to participate. All procedures were reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at Utah State University.

Materials/Assessment of PA

Each child was assigned a unique wrist accelerometer (Fitbit Flex, San Francisco, CA) that tracked the number of steps taken each day. This device provides reliable PA data by reporting daily step counts (Díaz et al., 2015). A series of 16 sequential FIT Game episodes were made available to the classroom teacher in PowerPoint format. These were projected using the classroom’s projector and whiteboard (See Figure 3-1 for an excerpt from one of the episodes). A PC computer equipped with Fitbit Connect (Fitbit Flex, San Francisco, CA) was used to sync children’s accelerometers with their
online Fitbit accounts. Individual students’ step-count data were downloaded from the Fitbit server and imported into a Microsoft Excel file.

Figure 3-1: Sample slide from the FIT Game
Procedures

An ABAB within-group reversal design was used, with “A” referring to no-intervention baseline phases and “B” to the FIT Game phases. Each phases lasted 10 days (2 school weeks). Throughout the study, teachers instructed children to put on their accelerometer in the morning upon arrival (8:30 am) and to take it off just before leaving school (2:30 pm); thus, PA levels reported are restricted to activity during school hours.

Baseline 1 (days 1-10): During the Baseline 1 phase, children wore their assigned accelerometers daily, as described above. The teacher provided no encouragement for children to be more active nor were children informed of their step counts. As is standard Fitbit function, children could obtain rough estimates for the number of steps taken by tapping the accelerometer face to produced illuminated dots, each representing 2,000 steps, to a maximum of five dots. Children were not informed of this function or the meaning of the dots.

FIT Game Phase 1 (days 11-20): On day 11, research volunteers oriented children to the FIT Game in a 10-minute presentation which outlined the object of the game – to help the heroes, the Field Intensive Trainees (FITs), to find and capture three villainous leaders of the Vegetation Annihilation Team (the VAT). Children were also informed that they (as a class) could assist the FITs by providing them with FIT energy when the class met or exceeded the PA goal for the day. It was explained to the children that the FIT energy enabled the FITS to power their ships and other equipment within the narrative of the game.
If the children collectively met their PA goal for the day, on the next day they were presented with the next in the series of 16 different FIT Game episodes, 15 minutes prior to recess beginning. In the approximately 2-min episodes, the children follow the FITs on their journey to track down and capture the VAT leaders before causing planetary destruction. The number of steps required to meet a daily PA goal was never disclosed to the children. Instead, they were encouraged to “move a little more today than you did yesterday during recess”. The researchers determined whether the daily goal was met if the average-per-student step count was at or above the $60^{th}$ percentile of the preceding 10 days of measured steps. That is, on day 11, the goal was the $60^{th}$ percentile of the step counts on days 1-10; on day 12, the goal was based on step counts on days 2-11. This percentile schedule of reinforcement (Galbicka, 1994) was used to continually adapt the goal to the children’s ability. In this way, the step-count goal is reduced if too high and increased if the goal is consistently met.

On days when the PA goal was not met on the previous day, the teacher informed the students that the next episode would not be presented until they met their goal (as adjusted by the percentile schedule of reinforcement). Phase 1 ended on day 20, after the eighth episode was shown (two days of missed goals). At this point, the children were informed that the game would pause for two weeks with the narrative depicting the FITs traveling through a wormhole, temporarily blocking communication.

**Baseline 2 (days 21 - 30):** During Baseline 2, data collection continued in the manner described in Baseline 1.

**FIT Game Phase 2 (days 31 - 40):** On day 31 the game resumed where it left off, with a new episode presented to the class. As in the prior FIT Game phase, PA was
measured daily and new episodes were contingent upon meeting PA goals set in the manner described above. The final episode, presented on day 40, depicted the supreme leader of the VAT being captured by the FITs.

Statistical Analysis

A repeated-measures one-way ANOVA was used to determine if differences existed between phases, using Bonferroni corrected post-hoc paired t-tests (alpha = 0.017) to compare differences between step-counts during baseline and FIT Game phases. All analyses were made using SPSS 24 for Windows (Armonk, NY: IBM Corp). Where differences were statistically significant, effect sizes were estimated using Cohen's $d_{av}$ (Cumming, 2011).

RESULTS

Figure 3-2 shows the average (± 1 SD) steps taken per child per day during the baseline and FIT Game phases. The repeated-measures one-way ANOVA showed a significant effect of phase ($F(3) = 17.4, p < 0.001$). From Baseline 1 to FIT Game Phase 1, PA increased significantly by 725 steps (20.3%) per child per day ($t(28) = 7.0, p < 0.001, d_{av} = 0.50$). During Baseline 2, the average number of steps returned to Baseline 1 levels ($t(28) = 0.8, p = 0.93$). When the game resumed in FIT Game Phase 2, PA increased significantly above Baseline 2 levels by 614 steps (17.3%; $t(28) = 4.3, p = 0.001, d_{av} = 0.54$). Step counts during FIT Game phase 2 was significantly higher than Baseline 1 step-counts ($t(28) = 4.4, p < 0.001, d_{av} = 0.42$).
Figure 3-2: Average-per-student steps taken during school hours during baseline and while playing the FIT Game (n=29)

During School Steps

<table>
<thead>
<tr>
<th>Phase</th>
<th>B1</th>
<th>FIT1</th>
<th>B2</th>
<th>FIT2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Step Count</td>
<td>3568</td>
<td>4293</td>
<td>3557</td>
<td>4171</td>
</tr>
</tbody>
</table>

Note: one-way repeated measures ANOVA show a significant effect of phase ($F(3) = 17.4, p < 0.001$)

* $p < 0.001$, Bonferroni post-hoc paired t-test phase comparison, Baseline1 to FIT Game 1

** $p = 0.001$, Bonferroni post-hoc paired t-test phase comparison, Baseline 2 to FIT Game 2

ǂ $p < 0.001$, Bonferroni post-hoc paired t-test phase comparison, Baseline 1 to FIT Game 2

DISCUSSION

The present pilot study evaluated the efficacy of the FIT Game adapted to target the behavior of PA instead of healthy eating. The FIT Game significantly increased PA in 6th grade students by an average of 670 steps at school per day during the FIT Game phases of the intervention. While these differences were small, they should be evaluated in the context of limited opportunities for improvement. That is, children wore their
accelerometers only at school and had only 15-mins of recess per day. In sum, the lower-labor version of the FIT Game, adapted to encourage more physical activity was successful in motivating greater activity at school.

Despite this initial success of the PA version of the FIT Game, this study is not without limitations. PA returned to baseline levels each time the Game was removed. While sustained PA levels are desirable, the purpose of this pilot study was merely to evaluate if the FIT Game could increase PA; sustained PA should not be expected from such a brief intervention. Some evidence suggests that health behavior change takes approximately 10 weeks before it becomes habitual (Lally et al., 2010) so it should not be surprising that activity levels reverted to baseline levels after 10-day intervals of FIT Game participation. Future research warrants a longer study duration to allow lasting effects to arise and long-term habits to form.

Future studies should evaluate the effect of the FIT Game on PA using a cluster randomized design with FIT Game and demographically similar schools serving as a control group. That study should also measure PA outside school hours. In the present study, accelerometers were left at school to ensure they were charged and synced daily. Practical limitations necessitated this arrangement, but these limitations are not insurmountable. Solving these logistic issues would open the possibility of positively influencing physical activity at home and school, and this is likely to have a larger impact on individual health.

Similar to our first unpublished implementation of the PA FIT Game, using the Fitbit server/software in a classroom setting continued to present technical limitations. Several of the Fitbit devices were unable to sync to the Fitbit server due to the high
volume of Fitbit devices present in the classroom, resulting in a data-transfer bottleneck. Despite the USB receivers continually “searching” for unsynced Fitbits throughout the day, data from the unsynced Fitbits were not detected. This was true even with several USB receivers present in the classroom. The Fitbit Flex is a consumer-grade accelerometer designed for single person use and as such, its USB receivers were not intended for more than one Fitbit at a time. This required a research-volunteer to be present each day after school to manually sync each unsynced Fitbit with the server. While this approach was successful for syncing and transferring data, it was time consuming and may not be feasible in larger-scale studies.

Despite these limitations, the present results are encouraging, as they suggest the FIT Game may be effective at increasing physical activity in children, as it has been in increasing FV consumption in the same population (Jones et al., 2014a, 2014b; Joyner et al, 2017). The decision to measure PA with the Fitbit Flex was made in hopes to facilitate daily recording of data but technological issues and the expensive cost of providing each child with one may warrant the use of pedometers in future research. Pedometers are cost-effective and do not require additional technology to implement but are subject to inflated step-counts if shaken. Incentives have been shown to encourage cheating (Just & Price, 2013); this could be problematic for FIT Game research as it motivates behavior with in-game incentives. However, pedometers are commonly used in PA interventions and past interventions (using incentives to motivate PA) have successfully used pedometers to measure PA without the occurrences of cheating (Hardman et al., 2011; Horne, Hardman, Lowe, & Rowlands, 2009). Future research might be designed to combine the healthy eating and physical activity goals of the FIT Game, addressing the
obesity epidemic through both dietary and activity modifications (CDC, 2015). Before simultaneously targeting FV and PA, it may be beneficial to alternate the focus every other day or week. If findings are favorable, then interventions targeting both FV and PA on the same days could be introduced, with combined contingencies that lower the threshold for success on FV consumption and PA, gradually returning to higher levels. To the extent that this can be achieved in a low-cost, low-effort intervention, that intervention is more likely to be adopted, correctly implemented, and sustained over time in elementary schools.
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CHAPTER IV

THE FIT GAME IV: EXPANSION AND EVALUATION OF A GAME-BASED APPROACH TO IMPROVE FV INTAKE IN SCHOOLCHILDREN

Consuming fruits and vegetables has been associated with a variety of health benefits including prevention of obesity, diabetes, cancer and cardiovascular disease (Centers for Disease Control and Prevention [CDC], 2014; Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004; Van Duyn & Pivonka, 2000). Childhood obesity currently affects more than one-third of the US population (Ogden et al., 2014). Because dietary habits formed during childhood are likely to carry on into adulthood (Kelder, Perry, Klepp, & Lytle, 1994; Maynard et al., 2006; Resnicow et al., 1998; Singer, Moore, Garrahie, & Ellison, 1995) reducing childhood obesity may be best addressed by focusing on healthy dietary behaviors such as increasing daily FV intake.

Interventions that take place during school hours may be preferential for modifying childhood behavior since the majority of U.S. children attend school for 6-8 hours (Madden, Price & Sosa, 2016). School-based interventions implemented at the elementary school level have the potential to motivate healthy behavior change because it targets early stages of pattern development and encourages lifelong patterns to continue (Webster, Monsma, & Erwin, 2010). Increasing fruit and vegetable (FV) selection in the school cafeteria can decrease the risk for childhood obesity (Finkelstein, 2008) but despite the efforts of the US Department of Agriculture to improve food selection in school cafeterias, children are not required to take a vegetable and still have the option to
take juice in place of their fruit (Johnson, 2016), which can contribute to low daily FV intake.

Several school-based interventions have seen short term success in motivating FV consumption in children using reward-based motivations (Horne et al., 2004; Horne et al., 2009a; Hoffman et al., 2011; Lowe et al., 2004; Wengreen et al., 2013; Joyner et al., 2017). Using tangible rewards such as small toys may be helpful in motivating healthy behavior change in children, although it can become costly if used for long periods of time (Madden, Price & Sosa, 2016) and may give the children a reason to cheat (Just & Price, 2013). The use of a game-based intervention could potentially resolve these concerns by offering in-game virtual rewards (Baranowski et al., 2011), in a previous study using in-game virtual rewards produced FV behavior changes that were similar to interventions with tangible rewards (Morrill et al., 2016).

A school-based intervention called the FIT Game uses in-game rewards and has consistently successfully encouraged healthy eating behaviors in elementary aged children (Jones et al., 2014a; Jones et al., 2014b; Joyner et al., 2017). The FIT Game is played during school lunch, where daily episodes follow a sci-fi group of heroes known as The FITs and their fictional space adventures trying to stop the evil Vegetation Annihilation Team known as the VAT. The narrative of the game is projected onto a large screen in the cafeteria of the school. Each episode, presented in a multiple-screen comic-book format, provides a section of the narrative, the continuation of which is contingent upon the children meeting daily FV goals. As children work together as a school to meet daily FV goals, they earn virtual currency that can be used to influence the
game. Children are provided an opportunity to vote on how the virtual currency will be used to help the FITs within the game.

Despite successfully increasing FV consumption during school lunch, there is limited evidence regarding the efficacy of the FIT Game for increasing children’s FV consumption over a period of time longer than 5 weeks. Our purpose for this research was to develop and evaluate the longer-term effects of an expanded FIT Game on school-level lunchtime FV intake. This expansion increased the duration of the game from 15 days to 39 days by: adding new events to the storyline that improved the character development, creating a variety of new mini-games/challenges and upgrading the character and story art. These improvements were done in collaboration with professional game-developers (Schell Games, Pittsburgh, PA).

Vegetable consumption was chosen as the targeted dietary behavior for improvement, due to vegetables being rated as less favorable for school children (Baxter, 2002) and being less likely to increase during a healthy eating intervention (Evans, 2012). A sub-objective of this was evaluating FV intake in participants by using skin carotenoid scans, which has been validated as an objective measure for usual carotenoid containing FV intake in children (Aguilar, Wengreen, Lefevre, Madden, & Gast, 2014; Ermakov, Sharifzadeh, Ermakova, & Gellermann, 2005). Carotenoids are plant pigments responsible for the bright orange, yellow, red, and green colors in some fruits and vegetables. Carotenoids cannot be made by humans, thus carotenoids measured in the human body are an indication of the amount of carotenoids consumed (; Aguilar, et al., 2014; Ermakov, et al., 2005). These scans measure total usual carotenoid levels
potentially offering insight into whether or not the FIT Game affects long term total FV consumption, including consumption that occurs outside of school hours.

METHODS

Participants

Children (n=702, grades 1-6) in two Logan, UT Title 1 elementary schools were invited to participate. Parents provided passive consent for their children to participate in the portion of the study that required collecting data on the lunchtime FV waste and active consent for the portion of the study that required us to take photographs of individual children’s trays for the purpose of estimating how much FV they consumed. Parents provided consent for 674 (92%) children to participate in the FV waste collection and 387 (55%) children to participate in the individual assessments of intake. This study’s design and procedures were reviewed and approved by the Institutional Review Board for the Protection of Human Subjects at Utah State University.

Materials

A scale sensitive to 1 gram (Ozeri, San Diego, CA) was used to obtain the averaged weights of the individual FV portions served in the school’s cafeteria as prepared by the food service workers. Aggregated FV waste was collected in two 37.9 L capacity bins and a larger floor scale (180-kg capacity, 0.1-kg resolution; EatSmart,
Mahwah, NJ) was used to weigh the FV waste. Individual lunchtime FV photos were obtained using iPad tablets (Apple, Cupertino, CA) running an app developed for this project to organize the photos by school, date, and ID (FoodPhoto, Utah State University, 2016).

On days when students voted to choose the direction of the storyline, three iPad tablets were provided for all students to anonymously cast their vote in an app that quantified and organized votes (Qualtrics, Provo, UT). The iPads were located on a designated table in the cafeteria near the exit to the room. Skin carotenoid concentrations were measured using a portable Raman spectroscopy device (Pharmanex, NuSkin, LLC). Each episode of the FIT Game was projected onto a screen (approximately 4 m x 4 m) in the cafeteria during lunchtime.

BMI for children participating in the individual portions of the study were calculated using the following formula: \( \frac{(kg)\text{/height}^2}{(m)} \). Height was measured to the nearest 0.1 cm using a Seca 223 stadiometer and weight was measured to the nearest 0.1 kg using a Detecto 758C digital scale. Participants were asked to remove their shoes and heavy clothing for height and weight measurements. Following these anthropometric measures, the children took a short survey, where they reported their grade and sex.

**Assessment of Group Level FV intake**

Estimations of FV consumed at the group level during lunchtime were obtained using a plate-waste measurement technique that our group has used in several previous studies (Jones, 2014a; Jones 2014b; Joyner et al., 2017). Before the lunch would begin,
research volunteers weighed and recorded weights for each FV item prepared by the school's food service personnel to be served that day; the amount of FV not served was weighed and recorded after lunch. During the lunch period, students who had finished eating their school-provided lunch would take their waste to a designated location where they would discard the uneaten portions FV into separate bins marked “fruit” and “vegetable”. The non-FV waste would then be placed into the school’s regular waste bins. We did not include FV measurements for children who brought home lunches; they discarded their FV wasted into the school’s waste bins. At the end of the lunch period, the labeled FV bins were weighed separately. The following equation was then used to estimate the amount of vegetable that was consumed, on an average-per-student basis:

\[
Consumption = \frac{P_v - U_v - W_v}{N}
\]

(Equation 1)

where \(P_v\) is weight of the prepared vegetables, \(U_v\) is the weight of the unserved vegetables, \(W_v\) is the weight of vegetables waste and \(N\) is the number of students who ate school lunch. The average amount of fruit that each student ate was also estimated using Equation 1, with fruit weights being substituted in the numerator. Plate waste estimations for group level FV was used every day during the baseline, intervention and follow-up periods.

**Assessment of Individual Photo Data**

After receiving their school-provided lunch and before sitting down, students involved in the portion of the study that required individual measures would bring their trays to a designated area in the cafeteria where research volunteers would individually
take a “before” picture of the child’s tray. Once the child was finished eating and before discarding food waste, they would return another designated table, where research volunteers would take an “after” picture, photographing the remaining food items on their tray. These “before/after” tray photographs took place on three consecutive days, at three independent times during the study: (1) baseline, (2) the final week of intervention and (3) at a three month follow-up.

Two trained research volunteers (who were blinded to the schools’ intervention/control assignments) independently reviewed the tray photographs, estimating each ID’s FV consumption by comparing the differences between “before” and “after” pictures. These FV photo estimations were made by assigning a percentage of consumed FV, with “0.0” representing no FV eaten and “1.0” representing all of the FV had been consumed (i.e. if they had eaten half of the FV portion, “0.5” was assigned for that item). This was done for all FV items served, with fruit and vegetable being estimated separately. In the case of FV estimates differing more than 20 percent, a third volunteer was brought in to break the tie; all reported FV estimates are within 80 percent agreement.

Individual FV consumption was calculated for each ID by first multiplying the average of the two estimated “percent consumed” by the actual serving size (grams). Next, each ID’s vegetable consumption (grams) was summed across three days (for all vegetable items) and divided by the number of vegetable items that each ID took, yielding an average amount of vegetable items consumed per day. The same methods were used to calculate fruit intake.
Assessment of Skin Carotenoid Levels

Skin carotenoid levels were collected on the same days as individual photos (baseline, end of intervention, follow-up) by trained research volunteers. Skin carotenoids have been validated as an objective measure of carotenoid containing FV in both adults and children (Ermakov et al., 2005). Carotenoids are plant pigments responsible for the bright orange, yellow, red, and green colors in some fruits and vegetables. They are potent antioxidants but cannot be produced by humans, thus carotenoids measured in the human body are an indication of the amount of carotenoids consumed (Ermakov et al., 2005; Mayne et al., 2010) with changes to concentrations taking approximately three weeks to manifest. The use of these scanners to detect differences in skin concentration levels has been validated for use with children (Aguilar et al., 2014). Skin carotenoid levels are an important factor to indicate whether increases in school-time FV consumption offset FV consumption at home.

Skin carotenoid levels for children participating in the individual measure portion of the study were measured using a portable Raman spectroscopy device (Pharmanex, NuSkin, LLC) by having the child hold his or her palm against the device’s light window. Carotenoid scans are painless and usually take less than a minute, making them a viable non-invasive technique to assess individual carotenoid concentrations. After each scan, the device would display a score (in Raman counts) that ranged from 0 to 70,000+. Each child was scanned twice and used the same scanner for baseline, intervention and follow-up periods. In the case of a difference greater than 2,000 Raman counts between the two scans, the child would be scanned a third time. The two scores that were within 2,000
Raman counts were averaged and this average was used in the statistical analyses described in this paper.

Procedures

One school was randomly assigned to serve as the intervention school; by default the other school was assigned as the control. The study began with a ten-day baseline period in each school after which the FIT Game was introduced in the intervention school for 39 school days; the control school did not receive the intervention. Three months after intervention’s conclusion, researchers returned to both schools for a 5 day follow-up period, collecting measurements for group FV intake, individual photos and skin carotenoid levels.

Baseline (10 days): During the first 5 days of baseline only group FV waste data were collected with normal cafeteria and school lunch routines, with the exception of requiring the children to sort FV waste into the appropriate bins. For the last 5 days of baseline, individual photo and skin carotenoid baseline measures were collected.

FIT Game Phase (39 days): This phase began with a school-wide assembly, where research volunteers introduced the FIT Game to the children, its heroes (the FITs) and its villains (the VAT) using a 2-3 minute PowerPoint presentation. The game’s objective was explained as the FITs recruiting the aid of the schoolchildren in their quest to put an end to the VAT and their galaxy-wide planetary destruction. The children were informed their assistance to the FIT would be in the form of providing them with daily ‘FIT Energy’ derived from cafeteria FV consumption. It was explained that the
schoolchildren would need to work together to eat more FV in order for the ‘FIT Energy’ to be of use to the FITs; if they did not increase FV intake, the FITs would be stalled and the narrative would stop.

Following the assembly, a new episode of the FIT Game narrative was presented in the cafeteria each day, contingent on the children working together to meet the previous day’s FV goal. The exact value to meet the goal was never objectively communicated to the children; instead, they were told to “eat a little more than you did yesterday”. The research team determined if each goal had been met based on if the average-per-student vegetable consumption was at or above the 50th percentile of the previous 10 days of data. This percentile schedule of reinforcement (Galbicka, 1994) allows the researchers to continually adapt the goal to the children’s ability (i.e. since the goal was always based on the previous 10 days of vegetable data, the next day’s goal was adjusted to allow for increased or reduced difficulty). When the children met the previous day’s goal, they were informed via the narrative that their FIT energy had been received, with the next few slides explaining how that energy was used (such as to power the thrusters for the FITs stranded ship). If the children did not meet their goal, an image of the disappointed FITs would be shown with the characters informing the children that not enough vegetable was consumed and to “try a bite of something new today”.

Throughout the storyline, the FITs would present casual but educational FV information highlighting the positive effects FV has on the FITs and their abilities. For example, in one episode, one of the FITs needs to outrun a horde of zombies and to do so, he consumes spinach, which he tells the children are a “good source of iron and iron helps you have energy throughout the day”. On randomly occurring days, the FITs would
be faced with mystery messages and riddles that they could not solve alone; help was solicited from the children through a school-wide vote that allowed each child an opportunity to submit their suggestion using iPads.

Throughout the game, the children earned virtual currency (FIT Points) that was used to purchase upgrades for the FITs (such as Mech-Boots allowing the FITs run at high speeds), with FIT Point totals being displayed at the beginning of each episode. FIT Points were earned when the children met consumption goals, the exact amount being determined by how much the daily goal was exceeded: one point awarded for every gram consumed above the goal. For example, if the goal was to consume 29 grams of vegetables and, on average, the school consumed 34 grams, 5 FIT Points would be awarded.

Toward the end of the FIT Game, the children had successfully helped the FITs apprehend several members of the VAT, shifting the game’s focus to finding and capturing the VAT’s leader. The final episodes of the FIT Game depict the leader of the VAT slowly closing in on the school, where he is ultimately seen roaming the school’s hallways. In the last episode, the FITs finally capture the VAT leader, awarding the school for their help.

**3-month Follow-Up (5 days):** No materials related to presenting FIT Game episodes were used during this period. Group FV intake, individual photo data and skin carotenoid baseline measures were collected as outlined above.
**Statistical Analysis**

Means and SEM were calculated for FV consumption and skin carotenoid scores after normal distributions were confirmed. Carotenoid scores exhibited a normal distribution but FV intake in both schools exhibited non-normal, zero-inflated distributions, with 54% of participants reporting 0 intakes of vegetables at baseline and 29% of participants reporting 0 intakes for fruit. To evaluate differences in baseline FV consumption between treatment and control schools, a t-test was conducted. Unless noted otherwise, all statistical analyses described in this section used a significance level set at p < 0.05.

**Individual FV consumption and carotenoid scores**: Pearson correlation coefficients and multiple linear regressions were used to examine the associations between age, sex, grade, FV consumption and carotenoid scores measured at baseline. Small, yet significant correlations among the three dependent variables (DVs) were found (carotenoid score and fruit intake: R=0.16, p=0.01; carotenoid score and vegetable intake: R=0.13, p=0.03; fruit intake and vegetable intake: R=0.15, p=0.001). Although correlations between the DVs were weak, significant interactions exist, warranting the use of a doubly-multivariate analysis of covariance (doubly-MANCOVA) for the three DVs over the three measurement periods: baseline, intervention, and follow-up. School served as the between-subjects independent variable, treatment (n=86 students who had measurements for all three phases) and control (n=100 students who had measurements for all three phases). Doubly-MANCOVA protects against inflated Type I error and takes into account the interaction of multiple DVs, whereas univariate or repeated
measures ANOVA do not. This reduces error variance, providing a more powerful test of mean differences among groups.

Doubly-MANCOVA is adequately suited to address violations of normality in large sample sizes (i.e. at least 20 degrees of freedom for error in a univariate ANOVA) and when the violations are not due to outliers (Tabachnick & Fidell, 2007). MANOVA’s robustness has been shown in non-normal distributions with sample sizes of only 20 participants per DV (Mardia, 1971) and even as low as 10 participants per DV (Seo, Kanda & Fujikoshi, 1995). For the current study, each DV included in the doubly-MANCOVA had greater than 20 subjects (186 participants for each of the three DVs).

A Roy-Bargmann stepdown analysis (Roy, 1958; Roy & Bargmann, 1958) was performed on the trend analysis of the DVs, with the three measures of vegetable intake as the first DV, fruit intake as the second DV, and carotenoid score as the third. Roy-Bargmann step down analyses test for group mean differences on a single dependent measure while controlling for the other DVs. The goal is to assess the contributions of various DVs to the significant effect. It is recommended as a follow-up procedure for significance in doubly-MANCOVA (Tabachnick & Fidell, 2007). Following the stepdown analysis, significant interactions were further explored with post-hoc independent t-tests. All post-hoc comparisons were adjusted for multiple comparisons using the Bonferroni adjustment.

Because a large portion of the participants had zero FV intakes a baseline, we sought to see how the FIT Game affected the odds of these “non-consumers” converting to “consumers” during the intervention period. A Logistic Multinomial regression (controlling for grade, sex, and BMI) was used to predict the odds of participants with
vegetable intakes equal to zero consuming FV during FIT Game phases, by school. The model's explanatory variable was calculated by dummy-coding each participant's baseline vegetable intake as zero (0) or greater than zero (1). Outcome variables in the model were calculated by dividing all participants into one of four possible categories based on vegetable intake during baseline and FIT Game phases: (yes/no vegetable at baseline and yes/no vegetable at end of intervention). All statistical analyses were conducted in SPSS 24.

**Group-level FV consumption:** comparisons between baseline and FIT Game Phases were made using a Simulation Modeling Analysis (SMA). The last ten days of data were used for baseline and intervention phase comparisons; follow-up phase comparisons were made using all five days. SMA analysis is better suited for short, individual-subject time-series data (Borckardt, Nash, Balliet, Galloway, & Madan, 2013) and offers protection against Type-1 and Type-2 error while at the same time providing adequate power to detect real effects of short stream time series data. SMA obtains a Pearson correlation coefficient (R) between the obtained time-series data and the dummy-coded (0 and 1) baseline and intervention phases, estimating autocorrelation in both intervention and baseline phases and correcting for small n-bias (Crosbie, 1994). 5,000 time series data streams are then randomly generated, using the same autocorrelation and number of observations per phase as is in the original data. P-values are obtained by calculating the proportion of randomly generated data streams with a correlation coefficient (against the phase vector) greater than or equal to the obtained correlation coefficient.
RESULTS

Table 4-1 shows the sex composition of the control and FIT Game (intervention) schools, as well as their average (+ SEM) baseline measures of BMI, skin-carotenoids, and FV consumption. There were no significant differences between schools on any of these measures.

Photo-estimated FV intakes and carotenoid scores

Table 4-2 shows average (+ SEM) FV intake and skin carotenoid levels, separated by school, across the three phases of the experiment. Because sex, grade, and BMI were significantly correlated with these three DVs, all subsequent analyses controlled for these covariates.

The assumptions of linearity, sphericity and homogeneity of variance for doubly-MANOVA were met. Results of the doubly-MANOVA revealed a significant school x phase interaction, $F(6, 720)= 8.1, p< 0.001, \eta^2= 0.06$. Thus, the change in healthy eating observed over the phases depended on the school – FIT Game or control. Homogeneity of regression was achieved for the Roy-Bargmann stepdown analysis. Vegetable intake, fruit intake and carotenoid scores were judged reliable as covariate DVs in stepdown analysis. Consistent with the results of the doubly-MANOVA, all three DVs showed significant stepdown effects for the school x phase interaction in linear trends: vegetable intake, $F(2,368)= 3.1, p=0.02, \eta^2= 0.03$; fruit intake, $F(2,367)= 17.3, p< 0.001, \eta^2= 0.08$; carotenoid score, $F(2,366)= 6.5, p= 0.006, \eta^2= 0.03$. 
Table 4-1: Baseline characteristics, by school, of individual measurements (n= 387)

<table>
<thead>
<tr>
<th></th>
<th>School</th>
<th></th>
<th>Between-group comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Intervention</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>n= 98</td>
<td>n= 94</td>
<td>t= 0.8, n.s.</td>
</tr>
<tr>
<td>Female</td>
<td>n= 103</td>
<td>n= 92</td>
<td>t= 0.8, n.s.</td>
</tr>
<tr>
<td>BMI (kg*m(^{-2}))</td>
<td>17.0 (± 0.2)</td>
<td>17.3 (± 0.3)</td>
<td>t= 0.04, n.s.</td>
</tr>
<tr>
<td>Carotenoid Level (Raman Counts) (n=186)</td>
<td>29,568 (± 604)</td>
<td>30,187 (± 781)</td>
<td>t= 1.2, n.s.</td>
</tr>
<tr>
<td>Veg Consumption (g) (n=186)</td>
<td>12 (± 1.2)</td>
<td>14 (± 1.4)</td>
<td>t= 1.5, n.s.</td>
</tr>
<tr>
<td>Fruit Consumption (g) (n=186)</td>
<td>33 (± 2.1)</td>
<td>32 (± 2.1)</td>
<td>t= 1.4, n.s.</td>
</tr>
</tbody>
</table>

Values reported as mean (± SEM)

n.s. = non-significant

Note: Table only includes data from participants who took part in the individually-measured portions of the study (i.e. photo data & carotenoid scans)
Table 4-2: Observed means for FV intake and carotenoid scans of treatment and control schools by phase (n= 186)

<table>
<thead>
<tr>
<th>Target Variable</th>
<th>Phase</th>
<th>Treatment School (n= 86)</th>
<th>Control School (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Intervention</td>
</tr>
<tr>
<td>Veg Intake (g)</td>
<td></td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Mean</td>
<td>± 2</td>
<td>± 2</td>
<td>± 2</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit Intake (g)</td>
<td></td>
<td>32</td>
<td>53</td>
</tr>
<tr>
<td>Mean</td>
<td>± 3</td>
<td>± 3</td>
<td>± 3</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carotenoid</td>
<td></td>
<td>30,187</td>
<td>37,256</td>
</tr>
<tr>
<td>(Raman Count)</td>
<td></td>
<td>± 1,066</td>
<td>± 1,060</td>
</tr>
<tr>
<td>Mean</td>
<td>± 679</td>
<td>± 784</td>
<td>± 747</td>
</tr>
<tr>
<td>SEM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figures 4-1, 4-2 and 4-3 summarize the estimated marginal means and SEM for FV intakes and carotenoid scores for each school, separated by phase. Post-hoc tests (adjusted α= 0.005) for between-school effects showed no differences at baseline in FV intake or carotenoid scores for treatment and control schools. At the end of the intervention period children attending the FIT Game school consumed significantly more FV than children attending the control school (+23 g of fruit, p= 0.001; +12 g of vegetables, p< 0.001). These differences remained significant at the 3-month follow-up evaluation (+17 g of fruit, p< 0.001; +7 g of vegetables, p= 0.001). Consistent with these differences, skin carotenoid scores were significantly higher in the FIT Games school both at the end of the intervention phase (+4,588 Raman counts, p < 0.001), and at follow-up (+3,799 Raman counts, p= 0.001).

Post-hoc tests (adjusted α= 0.012) for within-school effects showed that children at the FIT Game school ate more FV and had higher skin carotenoid scores at the end of the intervention period (p= 0.001) and end of the follow-up period (p= 0.001), than they did at baseline. There were no significant within-school effects observed for differences in FV intake or skin carotenoid scores among children at the control school.

To predict changes in carotenoid scores based on baseline FV intake two linear regression models (controlling for grade, sex and BMI) were conducted, with carotenoid score serving as the dependent variable in both (model two includes the photo-estimated FV intakes as independent variables). Model two predicted that for every gram increase of fruit, skin carotenoids would increase by 51 counts (p= 0.004) and for every gram increase in vegetable intake, skin carotenoids would increase by 80 counts (p= 0.002).
Figure 4-1: Estimated marginal means for individual-level, photo-estimated vegetable consumption, by phase (n=186)

![Bar chart showing vegetable consumption by phase for treatment and control groups.](image)

Error bars represent ± 1 SEM

Note: Doubly-MANOVA results of School*Phase interaction: F(6, 720) = 8.1, p< 0.001, η²= 0.06

Roy-Bargmann stepdown analysis for vegetable: F(1,184)= 3.1, p= 0.02, η²= 0.03

* = significant difference (p< 0.001) between treatment and control schools’ intervention (FIT Game) phases

** = significant difference (p= 0.001) between treatment and control schools’ follow-up phases

† = significant difference (p= 0.001) between treatment school’s baseline and intervention (FIT Game) phases

‡ = significant difference (p= 0.001) between treatment school’s baseline and follow-up phases
Figure 4-2: Estimated marginal means for individual-level, photo-estimated fruit consumption, by phase (n=186)

Error bars represent ± 1 SEM.

Note: Doubly-MANOVA results of School*Phase interaction: F(6, 720) = 8.1, p < 0.001, η² = 0.06

Roy-Bargmann stepdown analysis for fruit: F(1,183) = 16.7, p < 0.001, η² = 0.08

* = significant difference (p < 0.001) between treatment and control schools’ intervention (FIT Game) phases.

** = significant difference (p = 0.001) between treatment and control schools’ follow-up phases.

† = significant difference (p = 0.001) between treatment school’s baseline and intervention (FIT Game) phases.

‡ = significant difference (p = 0.001) between treatment school’s baseline and follow-up phases.
Figure 4-3: Estimated marginal means for individual-level carotenoid scores, by phase (n=186)

Error bars represent ± 1 SEM

Note: Doubly-MANOVA results of School*Phase interaction: F(6, 720) = 8.1, p< 0.001, η²= 0.06

Roy-Bargmann stepdown analysis for carotenoids: F(1,182)= 5.15, p= 0.006, η²= 0.03

* = significant difference (p= 0.001) between treatment and control schools’ intervention (FIT Game) phases

** = significant difference (p< 0.001) between treatment and control schools’ follow-up phases

† = significant difference (p= 0.001) between treatment school’s baseline and intervention (FIT Game) phases

‡ = significant difference (p= 0.001) between treatment school’s baseline and follow-up phases
R-squared was .030 (p = 0.06) for model one and .068 (p= 0.002) for model two (R-squared change of .038). Table 4-3 shows model summaries.

Table 4-3: Model summaries for linear regression, Carotenoid Score as DV (n=186)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Std. Error</th>
<th>P-value</th>
<th>Model R²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model one</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td>-229</td>
<td>369</td>
<td>0.54</td>
<td>0.030</td>
</tr>
<tr>
<td>Sex</td>
<td>-282</td>
<td>1093</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>-417</td>
<td>178</td>
<td>0.02</td>
<td>0.030</td>
</tr>
<tr>
<td><strong>Model two</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td>-439</td>
<td>360</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>-374</td>
<td>1069</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>-564</td>
<td>177</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Vegetable intake</td>
<td>80</td>
<td>26</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Fruit Intake</td>
<td>51</td>
<td>17</td>
<td>0.004</td>
<td>0.068</td>
</tr>
</tbody>
</table>

**Logistic multinomial regression**

A summary of the Logistic Multinomial regression for both FV can be seen in Table 4-4. Of the 480 children participating in the individually-measured portions of the study, 262 did not consume vegetable at baseline and 140 did not consume fruit. Results from the Logistic Multinomial regression show that, controlling for sex, grade and BMI,
children at the treatment school were 54% more likely to consume vegetables during the FIT Game period than those who were at the treatment school (OR= 1.54, p= 0.12). At the end of the FIT Game, the number of children who did not eat vegetables decreased by 13% (13 children less than baseline) at the treatment school and increased by 3% at the control school (5 more children than at baseline).

Controlling for sex, grade and BMI, children at the treatment school were 676% more likely to consume fruit during the FIT Game period than those who were at the control school (OR= 16.76, p= 0.001). At the end of the FIT Game, the number of children who did not eat fruit decreased by 50% (35 children less than baseline) at the treatment school and increased by 21% at the control school (15 more children than at baseline).

**Group Level FV Consumption**

Figure 4-4 summarizes group-level vegetable consumption (measured from cafeteria waste buckets) by school for baseline, intervention and follow-up phases. The mean value during the 10 days of baseline was 11 grams (SEM: ± 2.1) at the treatment school and 10 grams (± 1.2) at the control school. During the intervention phase, the treatment school increased consumption to a mean of 21 grams, or an 89% increase (± 14.5, R= 0.40, p= 0.06); the control consumption remained at 10 grams (± 1.4, R= 0.002, p= 1.0). At the end of the follow-up period, the treatment school maintained an increased vegetable consumption (compared to baseline) of 24 grams, 118% increase (± 9.4, R= 0.45, p= 0.11); control school follow-up values were lower than baseline, with a mean of
9 grams, 2% decrease (± 0.8, R= -0.03, p= 0.90). Vegetable intake did not differ significantly between treatment and controls for baseline (R= -0.12, p= 0.60) but was significantly different between schools during the intervention phase (R= -0.46, p= 0.03). The follow-up period did not differ in vegetable intakes between schools (R= -0.47, p= 0.17).

Table 4-4: Odds of baseline vegetable “non-consumers” (n=262, 54%) and fruit “non-consumers” (n=140, 29%) consuming FV during FIT Game phase

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>OR</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td>-0.35</td>
<td>0.97</td>
<td>0.90</td>
</tr>
<tr>
<td><strong>Grade</strong></td>
<td>0.05</td>
<td>1.05</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>0.05</td>
<td>1.05</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Did not eat veg at baseline</strong></td>
<td>0.15</td>
<td>1.16</td>
<td>0.94</td>
</tr>
<tr>
<td><strong>Treatment School</strong></td>
<td>0.43</td>
<td>1.54</td>
<td>0.12</td>
</tr>
</tbody>
</table>

| **Female**                       | 0.23  | 1.25  | 0.64    |
| **Grade**                        | 0.29  | 1.13  | 0.10    |
| **BMI**                          | -0.15 | 0.86  | 0.08    |
| **Did not eat fruit at baseline**| 0.13  | 1.13  | 0.98    |
| **Treatment School**             | 2.82  | 16.76 | 0.001   |

Note: all individually-measured participants were divided into FV "consumers" and "non-consumers" based on baseline FV measures being >0. The top panel shows the odds of a vegetable "non-consumer" eating vegetables during the FIT Game phase; the bottom panel shows the odds for fruit “non-consumers”.

Figure 4-4: Mean group-level vegetable consumption, by phase (n=1 school, 674 students)

Error bars represent ± 1 SEM
* = significant difference (p= 0.03) between treatment and control schools’ intervention (FIT Game) phases
Figure 4-5: Mean group-level fruit consumption, by phase (n=1 school, 674 students)

Error bars represent ± 1 SEM

* = significant difference (p= 0.02) between treatment and control schools’ baseline phases

** = significant difference (p= 0.02) between treatment and control schools’ intervention (FIT Game) phases

† = significant difference (p= 0.02) between treatment school’s baseline and intervention (FIT Game) phases

δ = significant difference (p= 0.02) between control school’s baseline and intervention phases

δ δ = significant difference (p= 0.02) between control school’s baseline and follow-up phases
Figure 4-5 summarizes objectively measured group-level fruit consumption by school for baseline, intervention and follow-up phases. The mean value during the baseline phase was 22 grams (SEM: $\pm 4$) at the treatment school and 41 grams ($\pm 2$) for the control school. During the intervention phase, the treatment school increased consumption to a mean of 42 grams, or 94% increase ($\pm 4.2, R= 0.64, p= 0.02$); the control school decreased to 24 grams, or 43% decrease ($\pm 3.2, R= -0.75, p= 0.02$). At the end of the follow-up period, the treatment school maintained an increased fruit consumption (compared to baseline) with a mean of 40 grams, or 85% increase ($\pm 6.9, R= 0.57, p= 0.05$); control school follow-up values were decreased from baseline with a mean of 24 grams, 41% decrease ($\pm 4.3, R= -0.69, p= 0.02$). Fruit intake between treatment and control schools was significantly different for baseline ($R= 0.71, p= 0.02$) and intervention phases ($R= -0.65, p= 0.02$); fruit intake for the follow-up phase was not significantly different between schools ($R= -0.54, p= 0.10$).

**DISCUSSION**

When children at the treatment school played the FIT Game, they increased their vegetable consumption by 12g (92%), fruit consumption by 23g (77%) and carotenoid levels by 6,661 Raman counts (22%). These increases remained elevated above baseline levels at the 3-month follow-up. The doubly-MANOVA analyses show a significant school x phase interaction for FV intake and carotenoid scores (controlling for sex, grade and BMI), indicating that mean FV intake and carotenoid score differed in each school by
phase. The effect size for this interaction was moderate ($\eta^2= 0.06$). The Roy-Bargmann stepdown analysis emphasize that all three DVs uniquely added significance to the differences between schools at each phase, implying that FV intake and carotenoid scores were all affected significantly by the presence of the intervention. Between-subject contrasts further this assumption, showing significant differences for all three DVs between treatment and control schools during the intervention and follow-up phases but no differences between schools at baseline. At the treatment school employing the FIT Game, significant differences from baseline measures where seen at the intervention and follow-up phases for all three DVs.

These results suggest that the presence of the FIT Game was able to successfully motivate increased consumption of vegetables during its implementation and despite the target of the FIT Game being vegetable intake, fruit consumption also increased. Evidence of its long-term effect on FV intake can be seen from follow-up measurements with FV intake and carotenoid levels remaining elevated above baseline levels. Despite only having a subsample of each school's population participating in the individual measures, the results are encouraging for the ability of the FIT Game to motivate FV over longer periods of time.

Results from the multiple linear regression and one-way ANOVA indicate that, based on baseline FV consumption, carotenoid levels were predicted to increase by approximately 2400 counts from baseline to the FIT Game phase and approximately 1920 counts from baseline to follow-up. For the treatment school, actual carotenoid levels for FIT Game and follow-up periods were 4251 counts and 2818 counts higher than predicted, respectively. These differences are estimated to be the equivalent of 0.93
servings and 0.57 servings of carotenoid containing FV (Aguilar et al., 2014) above what was visually estimated during FIT game and follow-up periods, respectively. Because carotenoid levels are a biomarker of FV intake, these results suggest that not only did the FIT Game successfully motivate FV consumption during school hours, but it may have influenced higher FV intakes outside of school lunch, during both FIT Game and follow-up periods. Although these comparisons are made using a sub-sample of the population due to lower participation in the part of the study that required individual measurement, they offer encouraging direction for future research.

The results of Logistic Multinomial regression offers insight to how the FIT Game affected those who consumed zero FV at baseline, predicting that non-FV eaters at the treatment school were more likely to consume FV during intervention periods if they were at the treatment school (although this probability was only significant for fruit non-consumers). After playing the FIT Game at the treatment school, the number of FV “non-consumers” decreased. Despite the number of “converters” being relatively low, this offers preliminary evidence that the FIT Game may be enough of a positive influence for these children to begin eating FV at school.

Group level data suggests that elementary school-children significantly increased their vegetable consumption by 89% when they played the FIT Game. While the comparison of baseline to 3 month follow-up period was non-significant, the mean for these values remained elevated (+118%) from baseline levels. These results are encouraging and suggest that the FIT Game may be able to produce increases in average vegetable consumption that are maintained three-month post intervention. While the target of the FIT Game was vegetable consumption, significant increases in fruit
consumption were also observed during the FIT Game’s implementation. Interestingly, the control school experienced a decrease in fruit consumption (group level data) in the baseline to FIT Game phase comparison. Despite there being no formal intervention in the control schools, the children may have reacted to the initial presence of research volunteers during baseline in the cafeteria visibly collecting information about FV consumption (e.g. Eckmanns, Bessert, Behnke, Gastmeier, & Rüden, 2006), briefly inflating FV consumption until the plate waste procedures became routine, allowing FV intakes to return to pre-baseline levels during the period of time the intervention was occurring in the treatment school.

The version of the FIT Game implemented in this research required no teacher involvement and had minimal material costs. FIT Game episodes were presented via PowerPoint using a projector and school-provided screen in the cafeteria during the 20 minute lunch period. The daily episodes each included verbal prompts encouraging the children to eat more vegetables. As indicated in a past implementation of the FIT Game (Joyner et al., 2017), vegetable increases during FIT Game Phases may have resulted from these prompts occurring during the children’s eating. The game also uses no-cost virtual rewards (e.g. FIT Points and the narrative’s continuation) that only require one study personnel to implement. These in-game rewards provide, as seen in previous research, an inexpensive method in which to encourage healthy eating (Baranowski et al., 2011); a novelty of the FIT Game is its ability to provide a game-based experience without the requiring the use of videogame platforms (Baranowski et al., 2008; Thompson et al., 2012), potentially facilitating its implementation into school districts.
While we did not directly measure the children’s interest in the FIT Game, consistently elevated consumption of FV during the FIT Game period suggest that the expanded narrative and character development for the FIT Game were successful in keeping the children’s interest throughout the FIT Game, despite being 20 days longer in duration than past implementations. The introduction of new challenges and mini-games were met with enthusiasm as long as the duration of these activities was kept to less than two consecutive episodes. Challenges of longer duration were not received well and many resulted in several students vocalizing their lack of interest.

The results of this study are encouraging, but not without limitations. First, future research could benefit from a stronger study design. The current research is a subset of a larger, four-school study design (at the time of writing the two additional schools are still collecting data due to a one-year difference in start dates). The current study’s two-school study design restricted statistical power and limited our analyses of group level data to short time-series SMA, which does not analyze school x time interactions. The results of these analyses are limited in causality and the interpretation thereof should be made cautiously. Second, despite having more than half (n=387) of each school’s participants involved in the individually-measured portions of the study, only 86 students (45%) at the treatment school and 100 students (51%) at the control completed measures for all three periods, which is a requirement for inclusion in the doubly-MANOVA. These analyses would have benefitted from a higher number of participants who completed measurements for all three phases, providing a higher amount of statistical power for inferences made about individual FV intake and carotenoid scores. Third, group level follow-up data (5 days) is not directly comparable to the data used for baseline and
intervention periods (10 days). This could introduce a higher level of variability and possibly explain why mean vegetable follow-up data was elevated about both baseline and intervention periods, yet non-significant. A factor furthering this limitation is that baseline and follow-up menu items were not matched (i.e. different FV served at baseline than at follow-up). As group-level data is determined by FV weights, providing different FV options introduces variability in weights, such as comparing corn and black beans (heavy weights) to broccoli and cucumbers (low weights).

Nonetheless, these results are not without value, suggesting the ability of the FIT Game to motivate and maintain elevated FV intakes during a longer intervention period and 3-months post-intervention. Carotenoid data implies that the FIT Game may have the ability to also increase FV consumption outside of school hours, potentially improving its impact as a healthy eating intervention.
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CHAPTER V
GENERAL DISCUSSION

Project Summary

The inability of children in the US to consume adequate amounts of fruit and vegetable (FV) each day has driven research toward establishing methods and interventions to show successful FV increases in the short and long term. Recent survey data from the National Health and Nutrition Examination Survey reports that less than ten percent of children meet FV recommendations (Kim et al., 2014; Krebs-Smith, 2010). Self-reported FV data tends to be inflated when compared to what is actually consumed (Archer et al., 2013; Nix & Wengreen, 2017), suggesting that actual FV intakes among children may be even lower than reported.

The FIT Game is a school-based intervention whose early and short-term implementations increased FV intakes by 61% and 57%, respectively (Jones et al., 2014a; Jones et al., 2014b). The research projects contained in this dissertation sought to build upon the existing framework of the FIT Game by lowering production costs, increasing the duration of the game in an effort to create longer lasting effects of FV intakes and modifying its contents to target physical activity (PA). If successful, the improvements to the FIT Game mentioned would strengthen its ability to motivate increase FV consumption over longer periods of time, perhaps creating lasting effects and translate to out of school environments. Lower implementation costs and targeting PA would also improve its value as a healthy behavior intervention for schools and is a necessary step in
the process of development a program that could be implemented on a wide school such as at a district, state, or national level.

This dissertation’s projects were organized in the following manner: first, evaluate the ability of a lower-cost, lower-labor version of the FIT Game to motivate FV intake (Chapter II). Second, (using the same low-cost, low-labor design) expanding the FIT game and evaluating its effect on FV intake over a longer intervention and follow-up measures (Chapter IV). And third, reorganize the FIT Game’s contents to target PA instead of FV intake (Chapter III).

In Chapter II, the low-labor, low-cost implementation of the FIT Game successfully increased FV intakes during intervention periods. In this version of the FIT Game poster presentations and teacher-read narratives of the FIT Game were replaced with PowerPoint slide-shows shown in the cafeteria. Short-term increases in FV were seen in both schools during the four weeks in which the FIT Game was played- these increases returned to baseline measures upon the removal of the FIT Game. This was the desired effect- demonstrating the ability of the FIT Game to improve the targeted behavior when incorporated and the absence of the effect when the FIT Game was removed. Not only did the lower-cost and effort version of the FIT Game improve FV while in play, it did so in amounts above previous findings: 99% vs 61% and 57% (Jones et al., 2014a; Jones et al., 2014b).

Chapter II’s results are encouraging and set the foundational framework to begin evaluating the long-term effects of the FIT Game. Research suggests that lasting behavior change can take up to ten weeks to develop (Lally et al., 2010). All of the previous FIT Game research use intervention periods lasting less than six weeks and do not measure
FV intake post-intervention. Chapter IV’s study was a subset of a larger, four-school project; because of delayed start times for two schools, Chapter IV’s evaluation was limited to the two schools that finished data collection in 2017 (one assigned as the control school and the other to receive treatment). This project’s main interest was to evaluate the ability of the FIT Game to motivate and maintain increased FV intakes over longer periods of time (ten weeks), at the both group and individual levels. The FIT Game’s materials were expanded in both depth of content and length and were played in the intervention school over the course of 39 days. After the cessation of the game, any lasting effects of the FIT Game were measured at a three-month follow-up.

Chapter IV’s results indicate that not only was the FIT Game able to increase and maintain increases in FV over the longer duration of three months, and the behavior of eating more FV was maintained even three months after the removal of the FIT Game. Although the absolute amount for FV increases was relatively small, increases were comparable to those of Chapter II and previous Food Dude and FIT Game research. Table 1 shows the comparison of FV increases at intervention and follow-up periods for Food Dude and FIT Game studies.

Until this point, the targeted behavior for the FIT Game has been FV intake. In Chapter III, we sought to determine if the FIT Game could influence other healthy behaviors in children, such as increasing PA. Most school-based interventions improve healthy behavior by targeting only one behavior, but evidence suggests targeting more than one type of behavior lends to a stronger healthy-behavior intervention (Driskell, Dyment, Mauriello, Castle, & Sherman, 2008; Kriemler et al., 2011; Sharma, 2011; O’Donnell, Greene, & Blissmer, 2014; Rush & Knowlden, 2015). To better understand
the specific effect that the FIT Game has on PA, Chapter III’s design piloted the modified-for-PA design of the PA. Results from this chapter support the ability of the FIT Game to target other healthy behaviors, with 20% increases in daily step counts. Despite limitations of small, classroom sample size, without a control group, these results offer preliminary evidence for future versions of the FIT Game as a multiple-behavior-change intervention.

Components of the FIT Game Contributing to its Success

The FIT Game uses several factors that have been identified in successful interventions such as FV objective measures, rewards, role models, repeated-exposure, progressive goal-setting and game-based elements (Jones et al., 2014). The principles are discussed in Chapter I. This dissertation’s projects offer valuable improvements to the already successful FIT Game. The cost of implementation was substantially reduced: past use of posters and teachers to further the game’s narrative was expensive ($20/day) and took time away from teaching obligations. As most schools have cafeteria projectors and screens, Chapter II virtually eliminated production costs and requires no time of teachers, benefiting most school districts whose financial restrictions would not allow a long-term implementation of the FIT Game. These benefits come without negative impact on observed FV increases.

Past versions of the FIT Game produced short-term increases in FV intake that were not measured in follow-up periods (see Table 5-1). Chapter IV’s expanded FIT Game produced increases in FV consumption that remained relatively constant
Table 5-1: Comparison of mean FV increases at intervention and follow-up for Food Dudes and FIT Game interventions during school lunch

<table>
<thead>
<tr>
<th>Study</th>
<th>FV increase at Intervention (g)</th>
<th>% Increase</th>
<th>FV increase at Follow-up (g)</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowe et al., 2004 (4 weeks, NA)</td>
<td>35</td>
<td>-</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Horne et al., 2004 (4 weeks, 4 months)</td>
<td>-</td>
<td>85%</td>
<td>-</td>
<td>52%</td>
</tr>
<tr>
<td>Horne et al., 2009 (4 weeks, 12 months)</td>
<td>12</td>
<td>55%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Upton et al., 2013 (3 months, 12 months)</td>
<td>8</td>
<td>15%</td>
<td>-5</td>
<td>-9%</td>
</tr>
<tr>
<td>Wengreen et al., 2013 (4 weeks, 3 months)</td>
<td>20</td>
<td>62%</td>
<td>12</td>
<td>40%</td>
</tr>
<tr>
<td>Jones et al., 2014a (4 weeks, NA)</td>
<td>9</td>
<td>60%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Jones et al., 2014b (6 weeks, NA)</td>
<td>19</td>
<td>37%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Chapter II (4 weeks, NA)</td>
<td>23</td>
<td>58%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Chapter IV (3 months, 3 months)</td>
<td>15</td>
<td>88%</td>
<td>15</td>
<td>88%</td>
</tr>
</tbody>
</table>

NA= No follow-up period in study design

Note: Lowe et al., 2004 did not provide baseline FV measures, only increases (g) from baseline to intervention; Horne et al., 2004’s paper reported consumption as percent increases; Horne et al., 2009’s follow-up period only measured home lunches and included juice as FV.
throughout the duration of the intervention and at follow-up. These extended periods of elevated FV consumption allows for habits to form, potentially creating a lasting behavior change among the children. Chapter IV’s design also allowed for treatment vs control school comparisons to be made, something that has not yet been shown with the FIT Game. As is the case with past FIT Game research, both FV intakes rose in the treatment school, despite the target being vegetable. Because of control school comparisons (which did not show FV increases), we are able to contribute the rise in fruit intake as being a byproduct of the game, ultimately providing unintentional improvements to untargeted healthy behaviors.

Because Chapter IV used carotenoid scores as a measure for intake of carotenoid containing FV, we were able to determine how the FIT Game affected FV intakes outside of school lunch. Individual post-intervention and follow-up carotenoid scores were higher than predicted (based on individual photo data) leading to the assumption that the FIT Game also has an effect on FV intake outside of the lunchroom.

Chapter III provides preliminary support of the FIT Game’s effect on other healthy behaviors. Because it successfully increased PA, there is reason to believe that the FIT Game can function as a motivator for multiple healthy behaviors. Future research warrants further investigation of its effects on PA with larger study designs, and its ability to integrate both FV and PA in a single intervention.
Limitations of the FIT Game

Despite Chapter’s II and IV targeting vegetable consumption, both FV intakes rose above baseline levels for intervention and follow-up measures. While school districts are not likely to complain of the additional rise in fruit consumption, it does raise some questions about the FIT Game’s possible lack differentiation between FV, such as: are the children able to tell the difference between a fruit or vegetable? Possible explanations include: the inability to distinguish between non-entrée items of related foods (FV are both non-entrée items and are both plant-based). Another may be that even though vegetables are targeted in the FIT Game, research volunteers collect both FV, leading to the thought that both count toward the game. Children separating FV for waste collection offers some evidence that they can indeed distinguish between a FV but may interpret fruit as a valuable part of the game due volunteers treating it equally with vegetables at the waste station. And finally, another possibility could simply be that they unwilling to eat the vegetable item and consume the fruit as a compromise. This is supported through research reporting children preference for fruit over vegetables (Baxter & Thompson, 2002) and that fruit is more likely than vegetables in to increase in interventions (Evans et al., 2012). Although the increases in fruit consumption are desirable behaviors, future implementations of the FIT Game may consider adding clarifying factors for targeted behaviors.

While we were able to successfully collect daily Fitbit information in Chapter III, it is not recommended for future versions of the FIT Game targeting PA. Because daily progression of the FIT Game requires objective data from the previous day, step count reports for all children are required to determine if the current day’s goal was met or not.
Fitbit Flexes were used to simplify this process by automatically recording each child’s daily steps but Fitbit servers and hardware are not designed for large group settings and often resulted in stalls for data uploading/syncing. This required research volunteers to individually sync and download step count data for each child, negating the benefits of using the Fitbit flex. The Fitbit Flex is also expensive and without the benefits of automated syncing, is not feasible for large or longer-term studies. Pedometers are cost-effective and may be a reasonable alternative to measuring PA. However, the incentives in the FIT Game may encourage cheating (Just & Price, 2013) which would be easier to achieve with a pedometer, as they are prone to inflated step-counts if shaken. However, pedometers have been used without cited cheating in past Food Dudes studies that also employ incentives (Horne, Hardman, Lowe, & Rowlands, 2009; Hardman et al., 2011).

**Limitations of School-Based Interventions**

Currently, the National School Lunch Program only requires students to take either a fruit or a vegetable. Because of this, difficulties arose when children would select fruit but no vegetable, disqualifying them from contributing to that day’s increases in vegetable intake. Additionally, one school in our research initially (first week of intervention) did not provide sufficient vegetable to allow all students to take one and were hesitant to provide more for fear of increasing vegetable waste (it was remedied by asking the lunch workers to provide at least one full serving of vegetable for each student during the intervention period). While understandable, the inability for all children to access vegetable items made it difficult to reach daily goals during those days, introducing a “ceiling effect” of what is possible, not because children would not eat but...
because of vegetable availability. And even if there was enough vegetable for each child to take one, the serving size could be another limiting factor for schools with high baseline FV intakes. According to the National School Lunch Guidelines (2012), schools typically offer FV in 0.75 cup sizes with recommendations for children to take one of each (1.5 cups of FV). While we did not experience any “FV ceilings” (average FV intake during the FIT Game for Chapters II and IV were 0.7 cups and 0.4 cups respectively), it is something to consider for future research.

Because our objective measurements of FV were based on weight, we had to consider the high level of variability in item weights when determining if daily goals were met (i.e. a serving of corn weights approximately double the weight of a serving of broccoli). For days with heavy vegetable items, a temporary solution (to determine if the group goal was met) was to calculate the percent of served vegetable consumed. Follow-up periods presented weight-based issues as well, especially since there was only five days of data. This resulted in a high level of variability in our group-level follow-up data in Chapter IV (Mean: 24g; SD: ±21 g). A suggestion for future research would be to match menu items for baseline and follow-up measures, removing the variability of different food choices available.

**Recommendations for the FIT Game**

Using the experiences from this dissertation’s projects, the following recommendations are made for future versions of the FIT Game: first, in place of identifying the targeted food by its name (i.e. carrots, broccoli or vegetables), begin using a “fun” name that the children will identify with (i.e. “FIT Food”). There has been
research supporting this idea, showing increases in consumption when vegetables names were replaced with “fun” titles such as “X-Ray vision carrots” (Wansink, Just, Payne, & Klinger, 2012). However, names implying superhero traits are discouraged as the children may not return to select that item upon discovering that they did not develop X-Ray vision.

Second, rearranging the selection of food items in the cafeteria so that vegetables are the first choice may improve their consumption by being the first and “easy” choice for children to take (Cohen et al., 2015; Redden et al., 2015). Also, targeted vegetable items would benefit from having an identifying sticker or FIT character pointing to it. Other studies have shown that this type of “branding” can increase FV selection and consumption (Wansink, Just, & Payne, 2012; R. M. Siegel et al., 2015; R. Siegel et al., 2016; Hanks, Just, & Brumberg, 2016; Hudgens et al., 2017). This may also improve the inability of the children to determine if a fruit or vegetable counts toward the game’s goals.

Third, younger children (especially those that can’t read, such as first and second graders) may find it difficult to decipher what is expected of them each day to help the progression of the game. The addition of images depicting one of the FITs eating the targeted vegetable item could help visually emphasize what is required to move the game forward. This may also benefit the problem of children not distinguishing the difference between fruit and vegetable selections.

Fourth, begin the integration of PA into the FV intervention. The FIT Game has much more experience motivating FV than PA in children, but Chapter III’s results offer encouraging results. Before simultaneously targeting FV and PA, it may be beneficial to
alternate the focus every other day or week. If findings are favorable, then smaller interventions targeting both FV and PA on the same days could be introduced to evaluate if children are able to focus on more than one healthy behavior in context of the FIT Game. While FV prescriptions in Chapter’s II and IV were broad (i.e. “eat a little more than yesterday”) both FV and PA may be able to increase more with more prescriptive prompts. This could be accomplished visually (i.e. show the proportion of the vegetable that each child would need to eat to reach the 60th percentile goal) or verbally (i.e. eat 3 of your 4 carrot sticks today”). Prompts for PA could be accomplished in a similar fashion, perhaps with the FITs modeling and explaining a new game to play at recess or giving “recess challenges” such as completing X number of laps around the soccer field or successfully performing X amount of jumping jacks in a specified amount of time.

**Conclusion**

The research within this dissertation was successfully able to lower the operating costs of the FIT Game, expand its contents for longer durations, demonstrate lunchtime FV increases (+15 grams) over longer periods of time and increase in-school PA (+670 steps) using a modified version of the FIT Game. Carotenoid data implies that the FIT Game may have the ability to also increase FV consumption outside of school hours, potentially improving its impact as a healthy eating intervention. The results from Chapters II-IV provide substantial improvements to the FIT Game and provide the groundwork for future FIT Game interventions. Overall, group behavior change was relatively small but consistent, perhaps providing potential for larger, future increases.
Considering limitations and future suggestions, the FIT Game is recommended as a healthy behavior intervention for elementary school settings.
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[https://doi.org/10.1016/j.ypmed.2012.07.012](https://doi.org/10.1016/j.ypmed.2012.07.012)
APPENDICES
April 18, 2018

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Dear Sheryl,

I am in the process of preparing my dissertation in the Nutrition department at Utah State University. I will complete my program in Spring of 2018.

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Signed: ___________________________
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Signed: _____ Lori Andersen Spruance __________________________
April 18, 2018

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I am in the process of preparing my dissertation in the Nutrition department at Utah State University. I will complete my program in Spring of 2018.

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Appendix B : License to Reprint Publication from *Games for Health Journal* as Chapter II

December 18, 2017
Damon Joyner
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Dear Karen,

I am in the process of preparing my dissertation in the Nutrition, Dietetics and Food Sciences department at Utah State University. I plan to complete my degree by May of 2018.

I am requesting your permission to include the attached material as shown. I will include acknowledgements and/or appropriate citations to your work and copyright and reprint rights information in a special appendix. The bibliographical citation will appear at the end of the manuscript as shown. Please advise me of any changes you require.

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Date: 12.20.17
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EDUCATION

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Dissertation title: Incentivizing fruit, vegetable and physical activity level change: Expansion and evaluation of the FIT Game program for healthy behavior change in elementary schools
Expected Graduation: May 2018

2014
University of Utah
B.S. Exercise Science

TEACHING EXPERIENCE

2018
NDFS 1020 Science and Application of Human Nutrition
Spring
Face-to-face, 122 undergraduate students
Role: Instructor- Course instruction, communication with students/administration, assigning final grades

2017
NDFS 5320 Advanced Sports Nutrition
Fall
Online, 12 graduate students
Role: Co-Instructor- Course instruction, student communication, coursework grading

2017
NDFS 5320 Advanced Sports Nutrition
Summer
Online course design and development
Role: Co-Course Developer- Creation of full semester layout, coursework and selection of relevant content

2016
NDFS 4020 Advanced Nutrition
Fall
Face-to-face, 48 undergraduate students
Role: Guest Instructor- Exercise and Bioenergetics module

2015
NDFS 1020 Science and Application of Human Nutrition
Spring
Role: Teaching Assistant
PUBLICATIONS

Peer-Reviewed Journals

1. **Joyner, D.L., Wengreen, H.J., Madden, G.J.** The FIT Game for Physical Activity: Expansion of a Game-Based Approach to Increase Physical Activity in Elementary Classrooms. (IN PROGRESS)


RESEARCH EXPERIENCE

2017  Incentivizing physical activity in school-children using a game-based approach.

**Role: Student investigator; program coordinator.** Lead production of intervention, communication with district/school administration, data organization/analysis. *Motivating physical activity in one sixth grade classroom at one school; Physical activity measured via Fitbit Flex*. (3 months).

2017  FIT Game III: A game-based approach to motivate increases in fruit/vegetable consumption and physical activity in children during school hours.

**Role: Student investigator; program coordinator.** Recruitment and oversite of student volunteers, construction/management of intervention, communication with school administration, data organization/analysis. *Motivating healthy behaviors (fruit/veg/physical activity) in four elementary schools (grades 1-6). Physical activity measured via visual observation; fruit/veg measured via plate waste, digital photography and skin carotenoid scans*. (6 months).
2016  FIT Game III: A game-based approach to motivate increases in fruit/vegetable consumption and physical activity in children during school hours.

**Role: Student investigator; program coordinator.** Supervision of student volunteers, communication with school administration, data organization/analysis. *Motivating physical activity and fruit/veg intake simultaneously in one elementary school (grades 1-5). Physical activity measured via Fitbit and visual observation; fruit/veg measured via plate waste. (3 months).*

2015  FIT Game II: A game-based approach to incentivize physical activity in children.

**Role: Student investigator; program coordinator.** Intervention development and implementation, communication with teachers and school administration, data organization/analysis. *Motivating physical activity in two fourth grade classrooms at one school; Physical activity measured via Fitbit Flex. (3 months).*

2014  Using a game-based model to motivate fruit/vegetable consumption among elementary aged-children during school hours.

**Role: Student investigator; program coordinator.** Assisted production of intervention, oversite of student volunteers, communication with school administration, data organization/analysis. *Motivating fruit/veg in two elementary schools (grades 1-5). Fruit/veg measured via plate waste. (3 months).*

**PRESENTATIONS**


*Published peer-reviewed abstract*
PROFESSIONAL MEMBERSHIP AND CERTIFICATIONS

Certifications

- American Heart Association: First Aid & CPR

Current Professional Memberships

- National Strength and Conditioning Association (NSCA), 2017-Present.

AWARDS


2017 Utah State College of Agriculture, Utah State Nutrition, Utah State Graduate Studies- Travel Award, 50th annual Society for Nutrition Education and Behavior national conference, $1,200.

2015 Utah State College of Agriculture, Utah State Graduate Studies- Travel Award, 48th annual Society for Nutrition Education and Behavior national conference, $1,200.

RESEARCH INTERESTS

Behavior economics in health and nutrition
Gamification and motivational factors for behavior change
Fruit/vegetable consumption in children
Physical activity in children
Wearable devices for physical activity measure
Body composition
Sports nutrition
Exercise programming and athletic performance
VOLUNTEER SERVICE

2017 Elementary Nutrition Seminars. 
*Spring* Series of basic nutritional seminars for two sixth grade classrooms.

2015 Repeated seminars relating to nutrition and athletic performance for sprint and endurance swimmers in the Northern Utah area.

2006- Full-time missionary, Lisbon, Portugal. 
2008 The Church of Jesus Christ of Latter-day Saints; Fluent in Portuguese

RELATED EMPLOYMENT

2010- 2017 Contracted Swim Coach, specializing in stroke technique and practice programming in high caliber high school and collegiate swimmers. 

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