Children's Physical Activity and Psychosocial Beliefs in Mobile Application-Based Physical Education Classes

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Dedication

This dissertation is dedicated to my husband, and my parents.

Abstract

Childhood obesity has become a national concern in the U.S. over the past decades. Offering quality physical education programs is one of the effective approaches of a variety of school-based physical interventions. To gain children's attention and their lack of interest in physical movement, physical education teachers have recently employed novel technologies, such as the iPad and exercise-related mobile applications. While many studies examined the effect of these devices on promoting individuals' physical activity in primary and fitness settings, few research was done on physical education settings. The purpose of this study was to examine the app-based physical education classes on children's physical activity and their psychosocial beliefs. Fourth and fifth grade children from two elementary schools (n = 157) participated in this study. Children from one school received a short-term app-based intervention while those from the other school participated in traditional physical education classes with limited technology use, serving as a comparison group. Children's sedentary, light and moderate-to-vigorous physical activity during physical education classes was measured with accelerometers. A battery of questionnaires was used to assess children's self-efficacy, outcome expectancy, social support, and enjoyment in physical education. Children in the app-based group spent approximately 21.3% of their class time on moderate-to-vigorous activity while children in the comparison group spent approximately 30.5% of their time. Both fell far below the recommended level of spending at least 50% of the class time on moderate-to-vigorous physical activity. The app-based group demonstrated significantly less increased percentage of time spent in both light physical activity (-6.2% vs. 4.2%), F (1, 154)

=97.7, $p < 0.001$, η^2 =0.39, and moderate-to-vigorous physical activity (-8.6% vs. -1.6%), F (1, 154) =31.4, $p<.001$, η_p^2 =0.17. The app-based group (14.8%) also had a significantly greater increased percentage of time in sedentary behavior than the comparison group (-2.6%), F (1, 154) = 110.6, $p < 0.001$, $\eta^2 = 0.42$. For children's beliefs, there was no significant differences in increases of all four beliefs between the app-based group and the comparison group. Correlation analyses of children's post-tests indicated that none of the children's beliefs was significantly associated with children's physical activity, while enjoyment significantly related to the percentage of time spent in moderate-to-vigorous physical activity in the comparison group. The results of the regression analyses indicated the four predictors explained 6.1 % of the variance in children's post-test moderate-to-vigorous physical activity in the app-based group, R^2 = 0.06, F (4,66) = 1.07, p = 0.38. In the comparison group, the four predictors explained 9.4 % of the variance in the percentage of time spent in moderate-to-vigorous physical activity, but the model was also not significant, R^2 = 0.09, F (4, 73) =1.89, p = 0.12. It appears that the app-based physical education classes were not effective in improving elementary children's physical activity and psychosocial beliefs, possibly due to a learning curve. A longer intervention period may be needed to witness true effect of app-based physical education classes on promoting children's physical activity and beliefs. It is also recommended that children themselves have more opportunities to engage in group activities using iPads and apps to benefit more from the features such as video playback to receive feedback on their own movements.

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Chapter One

Introduction

Children's physical inactivity has become a national concern. This issue is critical as obesity in childhood leads to an increased chance of chronic diseases such as diabetes and cardiovascular disease in adulthood (Centers for Disease Control and Prevention, n.d; Cruz, Shaibi, Weigensberg, Ball, & Goran, 2005). Consequently, much effort has been made to design effective physical activity interventions for children. One effective approach is implementation of a variety of school-based physical activity interventions such as offering quality physical education programs. Physical education classes are now recommended to engage children in moderate-to-vigorous physical activity at least 50% of class time (U.S. Department of Health and Human Services, 2010). However, in a systematic review, Fairclough and Stratton (2006) reported that, on average, children engaged in moderate-to-vigorous physical activity for only 34.2% of the class time — a value short of the aforementioned recommendation. This low percentage of moderate-to-vigorous physical activity during physical education may arise from teachers' increased instruction, demonstration, and organization time (Fairclough & Stratton, 2006) resulting from difficulty in getting children's attention, lack of sufficient feedback, or, possibly, children's lack of interest in physical movement. As such, physical education teachers have recently employed novel technologies, such as the iPad and exercise-related mobile application (a.k.a., app), to facilitate instruction and class management while being able to garner technology-savvy children's attention and interest (Cummiskey, 2013).

According to a systematic review, Bort-Roig, Gilson, Puig-Ribera, Contreras, and Trost (2014) suggested that these mobile device apps as physical activity intervention

tools help individuals adopt and maintain a physically active lifestyle. For example, apps can help individuals stay motivated as they keep track of their activities and receive timely feedback on their performance. Evidence has shown app-based physical activity interventions to be effective in increasing step counts in sedentary and overweight populations (Fukuoka, Lindgren & Jong, 2012) while also aiding in the increase of weekly brisk walking time and moderate-to-vigorous physical activity for older adults (King et al., 2013). Yet, most studies to date have examined the effectiveness of app-based physical activity interventions among adults in primary care and fitness settings. Only a few studies examined the impact of app-based interventions among children (Lubans, Smith, Skinner, & Morgan, 2014; Toscos, Faber, Connelly, & Upoma, 2008). Moreover, almost no known study investigated the effectiveness of mobile apps in physical education settings.

It is critical to examine whether psychosocial beliefs would vary as a function of the presence of apps in physical education, since these beliefs have been reported to be vital determinants in physical activity behavior changes. Social Cognitive Theory, widely used for predicting children's physical activity behavior, proposes that the interplay between behavioral factors, environmental factors and individual characteristics yields variability in human behaviors (Bandura, 1997). In other words, app-based physical education classes (i.e., environmental factors) may influence both the psychosocial beliefs (i.e., individual characteristics) related to Social Cognitive Theory (e.g., self-efficacy and outcome-expectancy) and physical activity behaviors (behavioral factor). Conversely, children with higher physical activity levels (behavioral factor) or stronger

psychosocial beliefs on physical activity (i.e., individual characteristics) may develop friendships with those who enjoy being active as well (social environmental factor). Thus, given this generation of children's greater interest in screen-based technologies than any previous generation, app-based physical education classes has possibility to improve the children's psychosocial beliefs.

Taken together, the current study provided children with an environment conducive to increased physical activity (app-integrated physical education) which might improve children's physical activity-related social-cognitive beliefs and their physical activity participation. Findings of this study are useful in understanding and designing an effective school-based physical education intervention to promote children's physical activity behavior.

Rationale

App-based physical education classes use certain apps that are known to be helpful in instruction, assessment, and management in the classes. Should the presence of these apps be effective in instructing children, and managing physical education classes, it should be manifested in a manner that increase children's physical activity participation and enhance their physical activity related beliefs. In other words, usage of apps in the classes can create an environment conducive of positively impacting children's physical activity behavior and their psychosocial beliefs. For example, the use of an app (Coach's Eyes) that has a video recording feature in a peer group activity can help children gain self-efficacy and social support, as children get to receive tailored and visualized feedback on their movement skills. Furthermore, educating children about

physical activity benefits in a fun and innovative way via apps can encourage children to improve their outcome expectancy of physical activity. Finally, children's enjoyment in the new technology used in physical education classes may translate into children's enjoyment in physical activity. Therefore, tying these characteristics of the app-based physical education to Social Cognitive Theory, the app-based environment would lead to change in 1) a personal factor; children's beliefs, and 2) a behavioral factor, namely increased physical activity and decreased sedentary behavior. Thus, specific aims and hypotheses were derived as follows.

Specific Aims and Hypotheses

This study employed a quasi-experimental design, where assessments were conducted twice, at the beginning (pre-test) and at the end (post-test) in both intervention and comparison groups.

Specific Aim 1: To examine whether mobile app-based physical education classes would promote elementary school children's physical activity from pre-test (sessions without app-integration) to post-test (sessions with app-integration).

H1: Children in the app-based physical education classes will demonstrate significant increase in accelerometer-determined physical activity levels from their pre- to post-test.

Specific Aim 2: To determine whether mobile app-based physical education classes would better promote elementary school children's physical activity than traditional instructor-led physical education classes (comparison group).

H2: Children in the app-based physical education classes will demonstrate significantly greater increase in accelerometer-determined physical activity levels than those in the traditional physical education classes.

Specific Aim 3: To examine whether a mobile app-based physical education group would enhance elementary school children's psychosocial beliefs (e.g., self-efficacy, outcome expectancy, social support, and enjoyment) from pre- to post-test.

H3: Children in the app-based physical education classes will demonstrate significant positive increase in psychological beliefs from pre- to post-test.

Specific Aim 4: To determine whether mobile app-based physical education classes would better enhance children's psychosocial beliefs than traditional instructor-led physical education classes.

H4: Children in the app-based physical education classes will demonstrate significantly greater increase in psychological beliefs than those in the comparison classes.

Specific Aim 5: To explore the relationships between children's physical activity and psychosocial beliefs in both the app-based- and comparison groups.

H5: All four psychosocial beliefs will positively predict children's moderate-to-vigorous physical activity in the app-based group while not necessarily in the comparison group.

Summary

In the era of children's physical inactivity being one of the risk factors to pediatric obesity, it is essential to seek effective physical activity intervention that would promote children's physical activity. As today's children are exposed to screen-based technologies more than ever before, if utilized in physical education classes, they may be considered as useful means to create effective physical education environment contexts where children would spend more time in moderate-to-vigorous physical activity levels by boosting their psychosocial beliefs. If app-based technology proves to be a facilitating factor to promote children's physical activity, many technological strategies to have children engaged can be provided to educators and health professionals.

Chapter Two

Literature Review

Overview

In this chapter, the literature review is outlined in the following order: (a) significance of childhood obesity in the United States as well as some of the correlates of this public health epidemic, such as physical inactivity and sedentary behaviors; (b) standards and current status quo of physical education in terms of children's physical activity, and particularly those of underserved minority children; (c) importance of psychosocial factors in changing physical activity behaviors and application of Social Cognitive Theory in changing this behavior; (d) literature review on mobile app-based physical activity interventions in various setting and populations; and (e) introduction of children and technology, and implementation of technology for educational purposes in general classrooms.

Childhood Obesity in the U.S.

One third of children and adolescents are overweight or obese (Ogden, Carrol, Kit & Flegal, 2012), which has become one of the pressing national concerns (Lytle, 2012). Specifically, the Centers for Disease Control and Prevention (2014a) reported that approximately 17% of children and adolescents aged between 2 and 19 years were obese in the United States. Race and ethnicity is one of the moderating factors in childhood obesity rates. Obesity prevalence rates for all youth ages 2-19 are higher for Hispanic, Mexican-American and non-Hispanic blacks than non-Hispanic white (Lytle, 2012)

Children's obesity risk is determined by body mass index percentiles using national growth chart which has children's height and weight data from the 1970s, categorized by gender (Lytle, 2012). Children in between the 15th and 85th body mass index percentile are considered as having healthy weight, while categorized as overweight if they are in the 85th to 95th percentile, and obese when at or above 95th percentile (Centers for Disease Control and Prevention, 2015a; Lytle, 2012).

Childhood obesity is a serious problem because it can translate into adolescence and adulthood with association to comorbidities such as cardiovascular, gastrointestinal, respiratory, and metabolic disease (Kohl & Murray, 2012); sleep apnea; musculoskeletal impairments; and psychosocial issues (Hopkins, DeCristofaro, & Elliott, 2011). Obese children have a negative body image, suffer from lower self-esteem, and feel depressed which leads to unfavorable academic and social progress (Kamik, & Kanekar, 2012). Economic burden for treatment of childhood obesity also speaks to the problem as annual hospital-related spending increased from 35 million dollars in 1979 to more than 127 million dollars in 1999 (Wang & Dietz, 2002). Although the childhood obesity rate has leveled off recently (Ogden, Carroll, Kit & Flegal, 2014), it still remains high.

Correlates of obesity. One of the key contributions to childhood obesity is energy imbalance, which means children take excessive energy consumption while expending fewer calories needed for development, metabolism, and physical activity. However, the risk factors for obesity are complex and should be approached in multi-aspects. For example, several factors that are linked to childhood obesity are genetic, sociocultural, environmental, and behavioral (psychological) (Hopkins et al., 2011;

Karnik & Kanekar, 2012). Children with genetic risk factors may have poor metabolism that leaves them with higher body fat percentages than those without genetic factor. Children who are cultured in homes, schools and communities that are not favorable to healthy food choices and physical activity may be more prone to be obese; or simply, children may have bad dietary habits or sedentary lifestyle that leads to an obesity problem (Karnik & Kanekar, 2012; Lytle, 2012).

To curb children's excessive weight gain, many initiatives and campaigns have been created. One example is the "Solving the problem of childhood obesity within a generation" initiative (White House Task Force, 2010) containing the Let's Move! Campaign (www.letsmove.gov). In this presidential report, more than 70 initiatives are categorized in the following five categories: (a) helping children to be in healthy environment from the early stage of their lives such as healthy child care settings and breastfeeding; (b) educating parents and caregivers to understand nutrition labeling ; (c) improving school nutritional services such as breakfast and lunch; (d) enhancing accessibility and affordability of healthy food; and (e) increasing children's physical activity opportunities before, during, and after school days (Lytle, 2012). One of the effective ways is through innovative behavioral modification approaches such as physical activity interventions. These physical activity interventions not only took place in school settings, but also home and community settings as well (Karnik & Kanekar, 2012). While genetic and environmental factors are hard to modify, children's physical activity behaviors are modifiable.

Physical activity and sedentary behavior. The national guideline suggests that children and adolescents get 60 minutes or more moderate-to-vigorous physical activity most days of the week to maintain healthy status, and the activities include aerobic, muscle, and bone strengthening exercise (U.S. Department of Health and Human Services, 2010). However, more than 50% of youth are not meeting the recommendation (Hallal, Anderson, Bull, Guthold, & Haskell, 2012). Specifically, data from recent survey indicates that 52.7 % of American students are not physically active at least 60 minutes per day on five or more days (Centers for Disease Control and Prevention, 2014b). Moreover, physical activity levels among children and adolescents have declined over the past few decades (Salmon & Timperio, 2007). This declining trend of physical activity participation is partially attributed to the decrease of engagement in active transport, physical education, and youth sports (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008) as well as the increase of the engagement in sedentary activity (Wojcici & McAuley, 2014). Increased sedentary time, such as television viewing and computer use, has been claimed as the culprits for this obesity epidemic. It is reported that, nationwide, 41.3% of students used computers in playing video games or something other than school work for three or more hours per day and 32.5% of students watched television three or more hours per day on an average school day (Centers for Disease Control and Prevention, 2014b). Meanwhile, physical activity declines as children age, adding more to this obesity epidemic (Craggs, Corder, van Sluijs, & Griffin, 2011).

Physical Education and Physical Activity Promotion

Contribution of physical education to daily physical activity. In an effort to fight childhood obesity, it is important to encourage children to be physical active. One way to promote children's physical activity is by physical education as most children are accessible at school, where they develop motor skills and learn the benefit of being physically active. Several studies have reported the contribution of physical education to elementary children's physical activity levels. Researchers reported that physical education contributed 8–11% of overall daily physical activity for children 11-14 years old (Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). Morgan, Beighle, and Pangrazi (2007) found that up to 18% of daily physical activity can be accumulated by low active children during a 30-min physical education lesson. More recently, researchers also found that physical education represented 15% of the least active and 6.4% of the most active 5th and 6th grade students' daily physical activity, respectively (Alderman, Benham-Deal, Beighle, Erwin, & Olson, 2012; Chen, Kim, & Gao, 2014).

Physical education standards. In 2004**,** the National Association for Sport and Physical Education, updated the standards of physical education that was first published in 1995. The national standards provide the framework for quality physical education program in the following aspects: develop competence in movement skills, understand the movement concepts, participate in regular physical activity, maintain health-enhancing level of physical fitness, exhibit social behavior that respects self and others, and value physical activity for health and enjoyment (National Association for Sport and Physical Education, 2004). Along with the national standards, each state implemented

state standards including benchmarks and activities examples for each grade. For example, the state of Minnesota issued standards called Benchmarking Project by the Health and Physical Education Quality Teaching Network (Minnesota Department of Education, 2014) to assist classroom teachers, curriculum developers or curriculum reviewers. In the standards, one of the benchmarks is using a variety of resources, including available technology, to analyze, assess, and improve physical activity and personal fitness plan (Minnesota Department of Education, 2014). As such, it is crucial to determine whether new technology such as iPad and mobile applications could be effectively utilized in physical education classes to promote children's physical activity and enhance their psychosocial beliefs toward physical activity.

Physical activity trend in physical education. An initiative of Centers for Disease Control and Prevention, and President's Council on Fitness recommends that students be engaged in moderate-to-vigorous physical activity for at least 50 percent of physical education class time (Centers for Disease Control and Prevention, 2009). Many physical education classes, however, do not provide enough time for students to engage in moderate-to-vigorous physical activity. Public elementary and secondary schools have reduced time allocated to physical education classes and recess due to the increase of budget and personnel in mathematics and reading (Eyler et al., 2010; Eyler, Nguyen, Kong, Yan & Brownson, 2012). Moreover, the length of physical education classes has been decreased 49 to 25 minutes per week (Eyler et al., 2010). Additionally, according to the 2014 School Healthy Policies and Programs Studies, the percentage of schools requiring physical education in each grade dropped from 45.1% in 5th grade to 29.4% in

7th grade and to 8.6% in 11th grade (Centers for Disease Control and Prevention, 2015b). Data also indicated that 52% of youth did not attended physical education classes one or more days in an average school week and only 29.4% of students went to physical education classes on a daily basis when they were in school (Centers for Disease Control and Prevention, 2014b). A survey on Californian schools reported that students are sedentary most of the class time in physical education, with only 4 minutes spent in vigorous intensity physical activity (University of California Los Angeles Center to Eliminate Health Disparities and Samuels and Associates, 2007).

Part of all these numbers can be due to teachers' ineffective instruction, resulting in children's lack of interest in physical movement, lack of sufficient feedback on their motor skill learning, and difficulty getting their attention (Sinelnikov, 2013). Since children are naturally attracted to screen-based technologies, if integrated into physical education sessions, children may find learning more interesting and fun, which in turn could address the problem.

Social Cognitive Theory in Physical Activity

Understanding the correlates and determinants of physical activity is a critical step in developing and designing effective interventions. And often theories do a good job in identifying the correlates and determinants. Evidence suggests that theoretically driven physical activity interventions are more effective than those without one, suggesting that theories are indeed useful in predicting, at least to some extent, human physical activity behavior.

Social Cognitive Theory (Bandura, 1986; 2004) has been extensively utilized to predict individuals' health behavior and persistence in the behavior. Based on the theory, human behavior can be explained by triadic and reciprocal interaction of individual characteristics, environmental and behavioral factors. In other words, one factor influences other factors in a unique way. For example, an individual's perceived competence (i.e., personal factor) can influence behavioral and environmental factors; whereas changes in environment can influence his/her behavioral and personal factors. This well-established theoretical framework has been frequently utilized for both the promotion and evaluation of physical activity in different populations including adults, adolescents, and children (Gao, Lodewyk, & Zhang, 2009; Gao, Newton, & Carson, 2008; Rothman, 2000; 2004; Winett, Tate, Anderson, Wojcik, & Winett, 2005), therefore, examining Social Cognitive Theory components in relation to physical activity is imperative in evaluation of physical activity interventions.

Self-efficacy. One major component in Social Cognitive Theory is self-efficacy. Self-efficacy is defined as situational ability beliefs an individual has about specific task performance, often when facing adversity (Bandura, 1997; Baranowski, Perry, & Parcel, 2002; Gao, Lee, Solmon, & Zhang, 2009). It is regarded as the most significant contribution of Social Cognitive Theory to the physical activity studies (Rhodes & Nigg, 2011), with much research indicating self-efficacy to be strongly associated with physical activity (McAuley & Blissmer, 2000). Self-efficacy is a multi-dimensional construct and include different types: barriers self-efficacy, support seeking (proxy) self-efficacy, and competing activities self-efficacy. An individual with higher levels of self-efficacy is

more likely to have stronger intentions, initiation, and greater persistence compared to those with lower levels of self-efficacy in school-based physical activity intervention settings (Gao, 2008a; Gao, Lee, & Harrison, 2008; Gao, Lodewyk, & Zhang, 2009). Furthermore, self-efficacy is found to be associated with physical activity behavior in adolescents (Sallis et al., 1992). Based on Social Cognitive Theory, mastery experience, verbal persuasion, vicarious experiences, and physiological and psychological states are some factors that can influence the levels of self-efficacy (Bandura, 1997).

Outcome expectancy. Other components that are essential to Social Cognitive Theory are outcome expectancy, social support, and enjoyment. As such, it is important to examine these factors along with self-efficacy. Outcome expectancy refers to an individual's beliefs that a specific outcome will follow after certain behavior (Bandura, 1997; 2004; Gao, Lee, et al., 2009). The assumption within Social Cognitive Theory is that people will act when they believe their behavior will lead to positive and valued consequences while avoiding the behavior that they believe will bring unfavorable outcomes (Williams, Anderson, & Winett, 2005). Outcome expectancy is generally composed of three independent concepts: physical outcome expectancy, social outcome expectancy and self-evaluative outcome expectancy. Physical outcome expectancy refers to beliefs about physical changes after engagement in the behavior. Social outcome expectancy relates to possibility of experiencing increased socialization, and self-evaluative outcome expectancy is about how individuals would feel about themselves. They are all important and each could uniquely contribute to behavioral change (Bandura, 1997; Wojcicki, White, & McAuley, 2009). All these outcome expectancies

result from engagement of an individual's behavior such as physical activity participation.

In addition, individuals differ in how outcome expectancy influences physical activity behavior and vice versa, as each has different needs and interests in engaging in the behavior (Gao, Lee, et al., 2009; Wojcicki, White, & McAuley, 2009). For example, an individual might not execute a behavior that may lead to positive outcome simply because he or she does not see the value of the behavioral outcome. In other words, outcome expectancy is dependent upon the interaction of (a) outcome likelihood and (b) outcome values (Rogers & Brawley, 1991, 1996). Specifically, outcome likelihood refers to the probability that a certain action will lead to a certain outcome, whereas outcome values refers to the value a person places to a certain outcome of the behavior (Gao, Lee, et al., 2009).

Researchers have suggested a positive relationship between outcome expectancy and self-efficacy (Gao, 2008a; Gao, Xiang, Lee, & Harrison, 2008). While some scholars suggested the interdependence of outcome expectancy and self-efficacy by showing that outcome expectancy had little influence on certain behaviors after self-efficacy was considered (e.g., Rovniak, Anderson, Winett, & Stephen, 2002), others reported independence of self-efficacy and outcome expectancy in the prediction of physical activity intention and behaviors (Gao, 2008a; Gao, Xiang, et al., 2008).

Social support. Another construct that is important to Social Cognitive Theory is socio-structural factors, which are related to various facilitators and impediments to behavior. Socio-structural factors are known to mediate the influence of self-efficacy on

behavior and include factors such as social support, impediments, and perceived environment. In this literature review, social support will be used to represent socio-structural factors because most studies on children's physical activity used social support. Social support refers to any behavior by others that assists in achieving goals or outcomes (Taylor, Baranowski, & Sallis, 1994). It is also concerned with how and to what extent others facilitate an individual's specific behaviors (Ten Dam & Volman, 2007). For example, schools can be an environment where social interaction impact children's behaviors. Social support is an imperative correlate of youth physical activity and can be originated from different sources such as parents, teachers, and peers. A few studies have examined the impact of family and friend support on children's physical activity and suggested that these social supports promote physical activity in children (Gao, Huang, Liu, & Xiong, 2012; van der Horst, Paw, Twisk, & Mechelen, 2007).

Enjoyment. Enjoyment refers to a psychological state characterized by fun and pleasure. It is integral in engagement of physical activity behaviors, as it is a central determinant of physical activity participation in children and adolescents (Barr-Anderson, Van Den Berg, Neumark-Sztainer, & Story, 2008). Enjoyment is an essential factor in understanding and predicting children's motivation toward behavior (Harter, 1982; 1985). Harter suggested that successful attempts in mastery experiences lead to enjoyment of physical activity behavior and consequently enhance perceived competence. Some factors that are shown to influence enjoyment toward physical activity in children are age (Anastasiadi & Tzetzis, 2013), teacher behavior and teaching methods (Smith & Pierre, 2009).

A positive relationship between enjoyment in physical education and perceived competence has been documented (Carroll & Loumides, 2001). Gao (2008b) also found that enjoyment and perceived competence predicted adolescents' physical activity. Additionally, in studies that examined children's enjoyment in technology-integrated (active video games) physical education classes, researchers reported that children's enjoyment was higher in the technology-integrated physical education class as compared with a traditional class (Gao, Podlog, & Huang, 2013) and that enjoyment was highly correlated with intrinsic motivation which predicted children's moderate-to-vigorous physical activity in playing active video games in physical education (Gao, Zhang, & Podlog, 2014).

Social Cognitive Theory in Children's Physical Activity

Literature that used Social Cognitive Theory for predicting children's physical activity often examined aforementioned constructs (e.g., self-efficacy, outcome expectancy or health beliefs, social support, and some other constructs such as self-regulation including goals and barriers (Bean, Miller, Mazzeo, & Fries, 2012; Elmore, Sharma, & Mches, 2014; Gao 2012; Martin, McCaughtry, Flory, Murphy, & Wisdom, 2011; Petosa, Hortz, Cardina, & Suminski, 2005; Ramirez Kulinna & Cothran 2011; Strauss, Rodzilsky, Burack, & Colin, 2001; Taymoori, Rhodes, & Berry, 2008; Trost et al., 1997; Winters, Petosa, & Charlton, 2003). Only a few studies used all four aforementioned constructs (Ramirez et al., 2011; Winters et al., 2003) and quite a number of studies included only selective constructs based on their hypothesized models (e.g., only self-efficacy, or self-efficacy and outcome expectancy). There were also a few

studies that included sub-constructs of self-efficacy (Martin et al., 2011; Trost et al., 1997) or sub-constructs of outcome expectancy (Petosa et al., 2005; Winters et al., 2003). Three literature examined physical activity using objective measures such as accelerometers (Gao, 2012; Struss et al., 2001) or pedometers (Ramirez et al., 2011). Most used self-reported questionnaires to recall children's physical activity levels and only two studies used a longitudinal design (Bean et al., 2012; Trost et al., 1997).

Best predictor for children's physical activity. All Social Cognitive Theory constructs predicted children and adolescents' physical activity behavior to some extent, however, self-efficacy seems to be the strongest predictor of children's physical activity. The constructs within Social Cognitive Theory were highly correlated to one another. One study reported self-efficacy as being the best and only predictor for children's physical activity (Sharma et al., 2005), while several studies reported both self-efficacy and social support being significant predictors of youth physical activity (Bean et al., 2012; Gao, 2012; Martine et al., 2011; Strauss et al., 2001). Self-efficacy and social support being important predictors supports the findings from a recent systematic review by Craggs and colleagues (2011) in which the authors reported that out of 62 potential determinants of change in children and adolescent's physical activity, higher self-efficacy, and social support consistently resulted in smaller declines in physical activity participation over time. Couple reported that all four constructs (i.e., self-efficacy, outcome expectancy, social support and self-regulation) to be predictors of physical activity (Ramirez et al., 2011; Winters et al., 2003) while one study reported that only self-efficacy and outcome expectancy were important predictors (Taymoori et al., 2008).

In another study by Petosa et al. (2005), the investigators revealed that self-regulation had the highest correlation with self-reported moderate-to-vigorous physical activity followed by self-efficacy and outcome expectancy. There was only one study (Elmore et al., 2014) that revealed none significantly predicted adolescents' physical activity. In this study, however, the researchers speculated that social support, the only predictor they did not include in their model, could have been the important predictor of physical activity behavior.

Social Cognitive Theory and physical activity in underserved youth. Some studies examined the relationships in underserved minority youth (Bean et al., 2012; Elmore et al., 2014; Gao, 2012; Martin et al., 2011) and it is noteworthy to check how different constructs of Social Cognitive Theory predict the physical activity behaviors in this population. The sample size ranged from 90 to 222 with children's ethnicity being either 100% Hispanic or majority (> 60%) being African American. Children's grade level ranged from 3rd to 7th grade. In three studies that examined this population, self-efficacy and social support were consistently found to be the important determinants. Gao (2012) found that self-efficacy and social support being significant contributors of Hispanic children's physical activity. Likewise, Bean et al. (2012) revealed that in elementary school girls, most of them being African American, self-efficacy and social support (peer and parent) had strongest association to physical activity at post-test. They further noted that those who had greater baseline social support, greater self-efficacy, and greater social support at post-test reported higher physical activity levels at the post-test. Similarly, Martin et al. (2011) also found that the best predictors of underserved middle

school adolescents' physical activity were self-efficacy and classmate social support. Elmore et al. (2014) did not find any significant predictors of physical activity in 222 African American older children, however, they attributed not seeing any significant predictors to not including the social support construct which is considered important to African American girls. Since most of these four studies are in line that self-efficacy and social support is significant contributor in predicting physical activity, health professionals and educators should consider these two constructs when they design physical activity programs especially targeting these underserved children.

Social Cognitive Theory and physical activity in different age group. Social Cognitive Theory constructs that predict children's physical activity may be different depending on their age. When comparing the relationships in children (Gao, 2012; Strauss et al., 2001) versus adolescent (Petosa et al., 2005; Taymoori et al., 2008; Winters et al., 2003), the studies seem to suggest that self-regulations and outcome expectancy were the important constructs in predicting physical activity in adolescents while self-efficacy was more salient predictor among elementary children's physical activity. In two studies (Petosa et al., 2005; Winters et al., 2003) self-regulation appeared as the most important predictor in explaining adolescents' moderate-to-vigorous physical activity. In Taymoori et al. (2008) study, self-regulation failed to appear as a significant predictor to Iranian adolescents' physical activity, but the researchers suggest that self-regulation may be best conceived as an antecedent of self-efficacy and not as a consequence in their study. In studies where target population was younger children, self-regulation construct was often not included at all in the models which is understandable as young children do

not possess or understand the concept of self-regulation. Likewise, outcome expectancy was not often the best predictors of children's physical activity either and this may be due to elementary children not yet possessing the cognitive ability to sufficiently realize the consequences of physical inactivity or benefit of physical activity (Gao, 2012).

Studies using different physical activity measures. The Social Cognitive Theory explained the variance in physical activity behavior overall was 18%. However there seems to be physical activity assessment moderating the physical activity effect size, since the Social Cognitive Theory models explained only 8% of the variance in physical activity in the studies that used objective measures (Gao, 2012; Strauss et al., 2001; Ramirez et al., 2011). The variance was higher (28%) in the studies that measured physical activity levels by self-reported questionnaire. This is in line with majority of the literature, where models generally explain more variance in self-reported physical activity than objectively measured physical activity (Plotnikoff, Luband, Penfold, & Courneya, 2014). This effect is partially attributed to common-method biases, where variance in physical activity measured by questionnaires is inflated due to the shared measurement method (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Mobile Application-Based Physical Activity Interventions

Recent report indicated that 64% of American possess a smartphone, with most of this population using it for emailing, texting, video calling, and internet surfing (Pew Research Group, 2015). Along with the popularity of smartphones, tablets are also popular because they offer larger screen with bigger storage and processing capability. What is attractive with these smartphones and tablets are that these offer numerous

downloadable applications (Pope & Gao, 2017). Mobile apps are computer programs that could run on smartphones, tablets, and laptop computers. Apps can be downloaded or purchased via distribution platforms such as the Apple App Store, Google Play, or Windows Phone Store (Martin, 2015). In 2015, the number of apps available on Google Play and the Apple App Store were 1.6 and 1.5 million, respectively (Statista, 2016). Of these apps, more than 160,000 apps were health-related apps which are also known as mHealth applications. Currently, the Intercontinental Marketing Services Institute of Health Informatics (2015) indicates that about more than one third of the available "Wellness Management" apps serve to improve fitness, while 17% and 12% of these health-related apps are for managing stress/lifestyle and diet/nutrition, respectively.

Apps on promoting physical activity. App-based interventions for healthy behavioral change (i.e., promoting physical activity) have been reported relatively successful in various populations and settings. These interventions utilized mobile or smart phones, or tablets to provide accessibility to related resources, allowing for sociability among participants and management of desired behavioral changes.

Studies on adults. Mobile technology has been used not only in various contexts such as healthcare, universities, or workplaces (Arnhold, Quade, & Kirch, 2014; Arsand, Tatara, Ostengen, & Hartvigsen, 2010; Carter, Burley, Nykjaer, & Cade, 2013; Glynn et al., 2014; Hebden, et al., 2014; Mattila, Lappalainen, Parkka, Salminen, & Korhonen,, 2010) but also to diverse populations in terms of age, ethnicity, health, and socioeconomic status (Bennett et al., 2014; Fukuoka et al., 2010; Hebden, et al., 2014; Fukuoka, Lindgren, & Jong, 2012; Turner-McGrievy et al., 2013). One of the studies that

examined the effectiveness of apps were on overweight adults where they had to track their weight and weight-related behaviors on newly developed app that served as a diary. The researchers found that weigh loss in participants was strongly associated with tracking their behaviors on the app (Mattila, et al., 2010). Several studies reported a success in weight loss or lowering BMI was correlated with adherence to the usage of apps (Carter et al., 2013; Hebden, et al., 2014; Turner-McGrievy et al., 2013) and that these results extend to various population groups such as minority adults (Bennett et al., 2014), sedentary female adults (Fukuoka et al., 2010; Fukuoka, Lindgren, & Jong, 2012) as well as university students and staff (Hebden, et al., 2014). In a study by Fukuoka et al., (2012), diverse sample of sedentary women was interviewed after app-based physical activity intervention in which they commented that the intervention monitored, motivated and mobilized them.

Likewise, a plethora of studies investigated the efficacy/effectiveness of mobile apps in the treatment/management of various disease and these studies reported significantly increased daily step counts or daily physical activity in general patients in primary care (Glynn et al., 2014), type 2 diabetes (Arsand et al., 2010), and chronic obstructive pulmonary disease (Nguyen, Gill, Wolpin, Steele, & Benditt, 2009; Verwey et al., 2014). Glynn et al. (2014), in their randomized controlled study wherein patients engaged in a smartphone application physical activity intervention which emphasized goal setting, and provision of regular feedback on patients on their physical activity level, the intervention group increased daily step counts over the course of 8 week, outnumbering that of control group.

Clearly, app-based interventions prove to be an innovative means to help adults engage in more healthy behaviors. As one of the effective features of apps was having participants track their health-related behavior and/or status, more studies need to examine how this strategy can be improved in an enjoyable way. Future studies are also warranted on how other features of apps can encourage participants to engage more in the target behavior such as provision of feedback and goal setting. As children and adolescents have limited access to smartphones and mobile apps, different strategies may be employed in using apps as the intervention tool.

Studies on children and adolescents. Almost half of children and youth in the United States are not as physically active as they are recommended, only 42% of children and 8% of adolescents (Troiano et al., 2008) meeting physical activity guidelines of 60 minutes of moderate-to-vigorous physical activity per day (U.S. Department of Health and Human Services, 2010). This generation of youth are highly interested in technology as they have been exposed to much technology than any previous generation, making them an ideal target for mobile app-based physical activity interventions (Pope & Gao, 2017).

Regardless of children and adolescents' huge interest in technology, there are not much studies conducted on these population, with most of existing studies on adolescents. First study on the topic was conducted by Toscos and colleagues (2008) in which they examined the effectiveness of mobile apps in increasing adolescent girls' step counts. They found that the girls not only increased their step counts but also reduced perceived barriers to physical activity over the two-week intervention. Social support

provided through the app played a big role in deceasing the barrier (Toscos, Faber, Connelly, & Upoma, 2008).

More recent studies with more rigorous study designs were also conducted. In Direito & colleagues (2015) study, the effects of two commercially available apps (Zombies, Run! 5k Training and Get Running-Couch to 5k) were examined on 14-17 years old adolescents' cardiorespiratory fitness. While adolescents randomized into either of the two app groups improved their fitness compared to the control group, no significant difference were observed. No difference was seen for secondary outcomes, objectively measure physical activity and psychological measures. The authors concluded that apps may not be sufficiently enough as stand-alone devices to influence changes in fitness and physical activity. Consequently, two studies were conducted to investigate the effectiveness of multifaceted school-based obesity prevention program known as "Active Teen Leaders Avoiding Screen-time", utilizing smartphone apps in low-income adolescent boys (Lubans, Smith, Skinner, & Morgan, 2014; Smith et al., 2014). Based on Self-Determination Theory and Social Cognitive Theory, the Active Teen Leaders Avoiding Screen-time intervention was effective in reducing the screen-time, sugar-sweetened beverage consumption, muscular fitness, and resistance training skills. However, no significant interaction effects were seen for body composition and physical activity, likely due to two reasons: program's focus on movement skill development, resulting in lower overall activity and poor compliance to accelerometry protocol (Smith et al., 2014).

As it is discussed, results for the effects of app-based program on youth are mixed. Whether it is stand-alone app program or multicomponent school-based intervention that used health-related apps, strategies to improve participants' compliance to the program requirement should be considered along with individually tailored approach within the use of apps. Along with improving children's physical activity levels, it is essential to improve their psychosocial beliefs related to physical activity as these are highly correlated. Thus, how these technologies have played a role in improving children's beliefs will be discussed.

Apps on promoting physical activity-related psychosocial beliefs. Mobile apps have many benefits in having individuals comply to exercise adherence, because they are useful in keeping physical activity profiles, goal setting, providing real-time feedback, social support networking and online expert consultation (Bort-Roig et al., 2014), which could contribute to increasing self-efficacy, outcome expectancy, enjoyment that may help build exercise habits. A number of studies have investigated how these mobile apps can help foster these positive physical activity-related beliefs (e.g., Appel, Huang, Cole, James, & Ai, 2014; Littman et al.,2015; Melton, Bland, Harris, Kelly & Chandler, 2015)

Studies on adults. Two studies examined how physical activity apps could influence exercise beliefs such as self-efficacy and enjoyment. In a study done by Melton and his colleagues (2015), 48 college students' motivation, social support, self-efficacy, and enjoyment were examined using a mixed-method design before and after 5 week-intervention to evaluate the effectiveness of exercise-based app ("Fitocracy" fitness app) on increasing these young adults' psychosocial beliefs in summer body conditioning

classes. Findings indicated that there was a significant difference in self-efficacy and family support between groups, favoring the app-based group. Notably, a significant improvement in self-efficacy was evidenced in the intervention group, indicating that app use might have contributed to participants' confidence in regulating exercise. Although no significant differences were seen for motivation between the two groups in quantitative analysis, in focus group, app users revealed increased motivation and feelings of enjoyment throughout the intervention period. (Melton, et al., 2015). However, the results of this study may have its limitation as participants' usage of the fitness mobile app was not tracked, suggesting future studies to take this issue into consideration.

In an observational study done by Littman et al. (2015), 726 participants were recruited online and asked to answer their use of exercise apps, self-reported physical activity levels, and their self-efficacy as well as barriers to exercise. Participants were divided according to their level of exercise apps usage, findings indicated that current users were more likely to be active (exercising two or more times a week), had higher metabolic equivalent of task (MET) expenditure across leisure, vigorous physical activity, and walking in comparison to participants who never used or discontinued using exercise apps. Additionally, a significant association were reported between current exercise users and decreased body mass index which was mediated by increased self-efficacy and exercise, and moderated by perceived barriers to exercise. In an essence, app use was associated with high levels of physical activity for participants who had more barriers to exercise. Authors concluded that exercise apps may increase exercise levels

and reduce body mass index by making it easier for users to overcome barriers and gain self-efficacy to exercise.

Studies on children and adolescents. Although limited, there were a few studies that examined the effectiveness of mobile apps in improving physical activity-related beliefs in children. Toscos and associates (2008), who examined the effectiveness of apps in increasing children's step counts found that sharing step counts with friends via mobile apps increased children's motivation to be active. Likewise, in a pilot study that investigated the feasibility of app (*Loseit*) use in self-monitoring diet and physical activity level in minority adolescents, researchers reported that students who used the app were motivated to eat healthier and exercise (Appel et al., 2014). This motivation in the app group, however, did not lead to more physical activity level compared to its comparison group. Although no difference in the proportion of participants engaging in physical activity was shown between the app group and handwritten group, the app group had significantly more participants who had correct knowledge in water consumption (Appel et al, 2014).

App use may play an important role in increasing youth's self-efficacy and changing the attitude toward physical activity. For example, more recent study by Watterson (2013), in which he examined the effectiveness of newly designed application (AFIT) in changing middle school students' attitude toward physical activity and nutrition using Self-Determination theoretical framework, found that the app use as a supplementary instructional tool in physical education over 4 weeks was effective in increasing students' physical activity confidence (i.e., self-efficacy) and perceived friend

support for meeting the nationally recommended physical activity level. Similarly, in an efficacy study that investigated the efficacy of mobile fitness game prototype in changing 12 adolescents' attitude toward fitness exercise, results revealed that the application's socialization features improved their attitudes toward fitness exercises such as sit-ups, jogging and jumping jacks (Lu & Turner, 2013). Although several studies report that app use motivates youth to be more active and improves their self-efficacy, this research topic is still in its infancy and is in need for more rigorous designs with theoretical background.

Most studies investigating the effect of mobile-app use on promoting youth's physical activity and their beliefs were done mostly on adolescents. This may be so because it is very unlikely for children to own a mobile device themselves. Thus, when it comes to children, interventions may be implemented in the class level within schools or under the guidance of parents or caregivers. In fact, more teachers are adopting the usage of mobile apps to facilitate their instructions and to improve students' learning. Therefore, it is timely concern to examine whether the integration of mobile technology in physical education would also assist teacher's instruction and allow more time for the children to be more active and positively impact their physical activity-related beliefs.

Children and Mobile Applications

Children in this generation are more digitally-oriented than any other generations. They are familiar with computers, tablets and smartphones and interact with the devices on a regular basis. According to Pew Research Center, approximately 75% of teens aged 13 to 17 years owned or had access to a smartphone and 91% of this population reported accessing the internet via mobile devices (Lenhart, 2015). Additionally, it is reported that

more than one third of primary school students use smartphones or iPads for education purposes (Nagel, 2013).

Mobile applications usage in physical education. According to a recent survey, approximately 39.4% of teachers utilized applications via tablet such as iPads or Kindle in classrooms and physical education (Kervin, Verenikina, Jones, & Beth, 2013). For example, some of exercise apps such as IronKids, Short Sequence: Kids Yoga Journey have been reported to improve children's skill development, excitement and perception of affiliation when incorporated in physical education lessons while some apps feature interactive educational components to facilitate the healthy behaviors in an enjoyable manner (Martin, 2015). For example, it was reported that children enjoy having the iPad and video record themselves via an app called iMovie while learning to volley serve in a third-grade physical education class (Daily Time Herald, 2013). Furthermore, in a famous blog, the author introduced several apps (e.g., Ubersense, Coach My Video) as video recording apps to help students analyze their technique and thus improve their performance in physical education (Aivaliotis-Martinez, 2013). According to this blog article, although the benefit of iPads and these apps were yet to be proved within physical education classes in improving student's performance, students were becoming more conscious and paying attention to their forms, locating areas to improve by watching their recording. The benefits of integrating these apps in physical education lessons are efficiency in providing verbal cues and visual representations for students to follow.

To operate mobile apps, iPad seemed to be the dominating tablet platform to execute apps. iPads with various apps have several roles in physical education setting.

First, iPads and apps are used as a communication tool such as a whiteboard, a scoreboard and display platform (Przybylski, 2012). Teachers can use the iPad to annotate skill cues, teams, new games, and drills as the notes can be wirelessly projected onto a screen in the gym. In terms of scoreboard, there is an app for every sport specific scoreboard and the scores can be changed easily with just a single tap. Second, it is used as classroom management tool serving as a timer, music displayer, and a microphone. With a use of music apps such as Garage Band, teachers can create, write, edit songs. This music effects can signal students to move from one station to another, or one piece of music can determine the time for working at a station (Pyle & Esslinger, 2014). Finally, the iPad and apps can serve as a tool for instruction, self-assessment, and feedback. Teachers can use the iPad and apps to record and analyze student's performance on certain skills for assessment. Teachers can also film, edit, and display videos of students demonstrating a skill and use those videos during instructional time There is also an app that serves as random team generators that would facilitate making teams and grouping easy and fast (Przybylski, 2012). With this method in team creating, there are fewer complaints of unfairness and many less feelings of exclusion (Przybylski, 2012). These are only a few examples of how apps can benefit in physical education classes. And there is a need to investigate whether this technology integration would benefit students in long run in terms of their satisfaction, performance, and compliance to physical education.

Some studies have discussed various strategies to incorporate these apps into physical education classes (e.g., Martin, 2015; Sinelnikov, 2013) however, empirical

studies examining the effectiveness of these apps in physical education setting are scarce. Two studies used apps in a multicomponent school-based obesity prevention program (Lubans et al., 2014; Smith & Pierre, 2014) but not in physical education setting.

To date, only one study examined how students' attitudes toward physical activity changed when an app was integrated as a supplement to physical education classes among 11 to 15 years old students (Watterson, 2012). Findings of his study indicated that the app use was helpful in increasing adolescents' psychosocial variables such as self-efficacy and perceived social support toward physical activity behaviors. However, the study examined only the efficacy of a researcher-created prototype app to be tested on adolescent cohort. The study also did not include any objectively-measured physical activity outcomes to confirm whether there was a change in actual physical activity behavior. Thus, this study investigated whether the integration of various commercially available free apps via a tablet could increase not only children's beliefs but also their physical activity behavior.

Summary

The literature review present background information on the obesity epidemic, children's physical activity and current physical education standards, and mobile app-based physical activity interventions in various populations. These interventions were proven to be effective in promoting physical activity and enhancing psychological variables for the adult population, however studies on children are much needed as the results have been mixed. Social Cognitive Theory (Bandura, 1997; 200) was used as a theoretical framework as the integration of mobile apps in physical education would be

related to students' enjoyment, motivation, and self-efficacy for the most part, as well as outcome expectancy and social support depending on how the apps are used in class. Recent literature supports the integration of mobile app into physical education classes as a means to better communicate, manage, and instruct in the class.

Chapter Three

Methods

Research Design

A quasi-experimental design with repeated measure was employed for this project with convenience sample recruitment to examine the effect of mobile app-integration in physical education lessons on children's physical activity and psychosocial beliefs. Four physical education classes (two fourth and two fifth grade) from one school employed app-based physical education lessons by an experienced physical education teacher, while four other classes in the comparison school engaged in traditional physical education curriculum by another experienced physical education teacher. All physical education teachers had a bachelor degree in physical education, and Minnesota certified physical education teacher. In each session, at least one teacher had over 20 years of experience. During the pre-tests, teachers at both the experiment and comparison schools did not use iPad and apps in their physical education sessions. Post-tests were conducted as teachers in the intervention group used apps in their classes. This design allowed us to investigate any interaction effects between the groups across time.

Participants

Fourth and fifth grade children (9-11 years-old) from two elementary schools (Anne Sullivan Communication School and Loring Elementary School, Minneapolis, MN) participated in the study. Anne Sullivan Communication School, serving as an intervention school, is a Title I school in which African American students make up 88% of the student body and 92% of students received free or reduced-price lunch in 2016 (Venture Academy, 2017). Loring Elementary School is also a Title I school where 40%

of student body are African American followed by 35% of White American students. Sixty-six percentage of students in Loring elementary school received free or reduced-price lunch in 2016 (StartClass, 2017). The intervention school has employed app-based physical education classes for fourth and fifth grade children; thus, matched (Title I, grade, sex) control school included only fourth and fifth grade students. Inclusion criteria were: (1) children enrolled in either school with regular participation in physical education classes: As we needed three sessions to determine the average of all physical activity-related outcomes, it was necessary that participants attend the physical education classes regularly; (2) children whose parent/caregiver provided parental consent and child assent forms: Since the project possessed only a minimal risk for children, the University Institutional Review Board passed a passive provision of parental consent form, which asked parents or caregivers to bring back the form only if they disagreed their child to participate in the study; (3) children who were free of any diagnosed physical and mental disabilities that could impede, prevent or be exacerbated by regular engagement in physical education lessons; and (4) children aged 9-11 years who were either in fourth grade or fifth grade.

Instruments

Outcome assessments were conducted at pre-test (first three consecutive physical education sessions) and post-test (fourth through sixth sessions). All assessments for children's psychosocial beliefs were self-reported and included the demographics measures. A battery of beliefs questionnaires was used to assess children's psychosocial

beliefs onsite at the end of physical education classes at pre- and post-test. Submitted data was unidentifiable and stored in a secure, password protected database on a computer.

Physical activity. For each class, physical activity levels during six consecutive physical education sessions were assessed using ActiGraph GT3X+ accelerometers. Accelerometers are small devices that count physical activity level in three phases. With accelerometers it is possible to get information on physical activity levels at different intensities, energy expenditure and step counts. Accelerometers were worn on a waistband at the right side of children's hip. Given the short duration of the physical education class, activity counts were measured in 1 second epoch, and physical activity levels were quantified as average counts per 1 second for activity intensities. Counts were classified as sedentary behavior (0-25), light physical activity (26-573) and moderate-to-vigorous (574-1002 for moderate) physical activity using established cut points (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008). Children's mean percentage of time spent in sedentary behavior, light physical activity and moderate-to-vigorous physical activity over the first three sessions and last three sessions were used as outcome variables for pre-test and post-test, respectively.

Demographics. Demographic information obtained for the children participants included age, gender, grade level, race, and date of birth for descriptive statistics. Children provided this information prior to the psychosocial assessment with the guidance of the investigator and teacher.

Psychosocial beliefs. Children's psychosocial beliefs were assessed with a battery of validated questionnaires (Gao, Lee, Kosma, & Solmon, 2010; Gao et al., 2012;

Gesell et al., 2008; Ommundsen, Page, Ku, & Cooper, 2008) and were distributed one at the pre-test and the other at post-test. The questionnaires include psychosocial variables examining self-efficacy, outcome expectancy, social support, and enjoyment. The response scores for all surveys were revised to dichotomous choices from the original five-point or seven-point Likert scales, because it was reported by Gisell et al. (2008) that dichotomous responses were suggested to be easier to understand and respond to 4th and 5th grade children from low-income families.

Self-efficacy. A six-item questionnaire used in a study by Gao et al. (2010) were used to assess children's beliefs in their ability to be physically activity in physical education class. Gao et al. (2010) demonstrated acceptable validity and internal consistency for the questionnaire (alpha= 0.70) The stem asks: "With regard to the activity in the physical education class today, I have confidence in…" The sample answers were (a) my ability to doing well in this activity; (b) my ability to learn skills well in this activity; (c) my performance in this activity; (d) my knowledge needed to do well in this activity; (e) my success in this activity if I exert enough effort; and (f) my ability to handle the anxiety related to this activity. Children were asked to respond to each item dichotomously, either 1 = Yes or 0 = No, and the sum of the six items were used for children's self-efficacy score.

Outcome expectancy. To assess children's outcome expectancy, the adjusted Beliefs Scale used by Gesell and colleagues (2008) were used. The Beliefs Scale was adapted from a previously validated 16-item Beliefs Scale (alpha = 0.58-0.75, test-retest = 0.51-0.69). The 12-item adjusted scale consisted of two subscales, physical outcomes

and social outcomes. Among these 12 items, four items are negatively framed and therefore, reversely coded. The stem statement was "If I were to be physically active in physical education class" and children were asked to answer dichotomously (i.e., yes or no) to statements such as follows: "it would get or keep me in shape", "it would make me better in sports", "it would help me be healthy". Examples of the negatively framed questions are "it would be boring" and "it would make me get hurt." The sum of these 12 items were used as an indication of children's outcome expectancy.

Social support. A scale was adopted from Gao et al. (2012) to measure children's perceived social support. The 11-item original scale comprised four subscales of parental support, parental encouragement, peer support, and teacher support. In this study, however, since the children were asked for the perceived social support within the physical education class, the scale included only the subscales of peer support and teacher support. Children were asked to answer yes (1) or no (2) to five items to indicate their perceived teacher and peer support. The sum of the five items were used as children's score for perceived social support. The sample items included were: "Does your physical education teacher tell you to exercise or play sports?", "Do your friends exercise or play sports with you?" The internal consistency (alpha = 0.76) has been evidenced by Ommundsen et al. (2008).

Enjoyment. To measure children's enjoyment toward participating in physical education class, adjusted scale from the Enjoyment-Competence Scale used by Ommundsen and colleagues (2008) were used. The original Enjoyment-Competence Scale has eight items with two subscales: Perceived competence and enjoyment (alpha =

0.51-0.62). Only the five items assessing enjoyment factor were used, asking children's enjoyment in participating in physical education. Children were asked to respond either yes (1) or no (0) to statements: (a) I have more fun doing physical education than doing other things; (b) Doing physical education is the thing I like to do best; and (c) I wish I could do more physical education than I get chance to; (d) I usually prefer to watch rather than be physically active in physical education; and (e) I really like doing physical education at school. The sum of all five statements was used as children's enjoyment score.

Procedures

As advised by university IRB, consent forms were sent home one week before the start of the data collection asking parents/caregivers to send the form back only if they disagreed their children in participating in the study. All participants completed assent forms at the beginning of all the assessments. Both forms can be found in Appendix C.

Research settings. Two schools participating in the study were within Minneapolis Public Schools that offered one or two physical education classes per week. Two fourth grade physical education classes and two fifth grade physical education classes from each school were recruited in the study. The physical education classes in both schools were scheduled for 50 minutes per session and led by certified physical education teachers. Physical education classes were offered between 1:35pm to 2:25pm at the intervention school, and 11:35am - 12:25pm at the control school. From the intervention school, two fourth grade classes and two fifth grade classes comprising of

about 20 students each were selected to participate in the study while at the control school, three classes of 30 students combining 4th and 5th graders in each class participated. Each student was pre-assigned an identification number that matched the accelerometer number and the accelerometers were distributed to children at the beginning of the physical education classes. The accelerometers were collected at the end of each physical education class. The psychosocial belief questionnaire assessment, which took approximately five to eight minutes to complete, were taken at the end of the third and sixth physical education classes at both schools.

Intervention conditions. For the first three physical education sessions in the experimental group, the lessons were conducted without using iPads and apps while the last three sessions instructed with the technology tools. In the 50–minute app-based physical education lessons, children were instructed with the iPad and various apps related to learning sport skills, exercise and physical activity. There were two fourth grade classes, consisting of 26 and 27 children, respectively. These two classes had physical education classes during 1:35-2:25 pm five days a week for six weeks and led by two certified physical education teachers. After the six weeks, two fifth grade classes, each comprising of 17 and 19 students, had physical education classes scheduled at the same time as the fourth graders for six weeks. Children's physical activity data were collected on Tuesdays and Thursdays for six sessions instead of six consecutive sessions, to match the data collection span in the control group.

During the app-integrated sessions, the teachers had the content of the apps on iPad visible to children via wireless projection on the gym wall. This was possible by

having the iPad wirelessly synced to a laptop which is connected to a projector. Examples of some of apps that were used were “Scoreboard” to keep track of scores when playing a sport game; “Garage Band” which allowed teachers to use various music to shift between activities and instruct students stay still; “Educreation” which served as a whiteboard to teach fitness and health concepts; and “Coach’s Eye” for providing feedback by recorded video clips as students learned a motor skill. Sample of how physical education classes were taught are presented in Appendix B. For intervention quality, the research assistant was present during all intervention period to ensure that teachers were employing apps during entire classes.

Conventional physical education classes. Classes in the comparison group were slightly different from the app-based group. In the school, a class consisting approximately of 30 students had mixture of both fourth and fifth graders. There were total of four classes of this kind, so only three classes were chosen to participate in the project. These classes had physical education lessons during 11:35am- 12:25pm either once or twice a week, depending on which day of the week they had physical education. Any classes that had physical education scheduled on Monday had another lesson on Friday, thus having physical education twice a week while others had only had once. The class who had physical education on Monday was rotated throughout the semester. All three classes that participated in the project were taught by the same certified teachers. The main teacher had been a certified physical education for 28 years and the other was a pre-service teacher with an experience of one year. A research assistant was present during classes to make sure that no technology was used.

The control group had similar lesson plans with the main difference being that all contents were delivered without technology integration. Similar to the app-based group, the session was 50 minute-long and the curriculum comprised of warm-up, fitness training, a single sport skill practice followed by a game using the skill practiced.

Data Analysis

The questionnaires were coded and reverse-coded for the designated items. Then data were screened for missing values, normality, outliers, and errors. Means and standard deviations for the demographic information and all outcome variables were calculated. Additionally, power analysis to determine the sample size was conducted with the pilot test data. To ensure that the two groups were equivalent before the beginning of the study, a series of analyses of variance (ANOVA) were conducted to examine if differences existed on the demographic backgrounds and all outcome variables. Additionally, Cronbach's alpha coefficients were obtained to examine the internal consistency of the questionnaires for reliability.

To examine children's physical activity levels, the accelerometers counts were converted into minutes and percentages of time spent in sedentary behavior, light, and moderate-to-vigorous physical activity. The averages of the percentage of time spent in each of these three behaviors (i.e., sedentary behavior, light, and moderate-to-vigorous physical activity) were the outcome variables.

To answer the first hypothesis, a series of dependent t-tests were conducted to examine the within group differences in children's sedentary behavior, light, and moderate-to-vigorous physical activity.

To analyze the second hypothesis, ANCOVA with race as a covariate was conducted. The analyses were to investigate between-group differences in the changes of percentage spent in different intensities of physical activity over time.

To test the third hypothesis, multivariate analysis of variance (MANOVA) with repeated measures were conducted to examine the within group differences in children's psychosocial beliefs.

To answer the fourth hypothesis, multivariate analysis of variance with race as a covariate (MANCOVA) was conducted. Children's changes in scores for self-efficacy, outcome expectancy, social support, and enjoyment were compared between the app-based and the comparison groups.

Finally, to analyze the last hypothesis, which was to examine the relationships between children' beliefs and percentage of time spent in moderate-to-vigorous physical activity, Pearson's correlation analyses and multiple regression analyses were conducted. Significance levels were set at .05 for all analyses except MANOVA and MANCOVA. For these analyses, the significant level was set at 0.01. SPSS (version 21.0 SPSS IBM Inc, Chicago, IL) were used for the data analyses.

Chapter Four

Results

Preliminary Study

Preliminary study was conducted three months prior to the actual data collection at the two schools to examine the comparability between the two schools. Total of 174 students participated in this baseline study. No intervention was conducted at this time. Children's physical activity level during three physical education sessions were collected via accelerometers, and children's psychosocial beliefs were assessed at the end of the third (the last) physical education session, Analyses for the preliminary study were conducted to examine any differences in the demographic and outcome variables at baseline. The demographic information of the preliminary sample is provided in Table 4-1.

Demographic variables. Analysis of variance was conducted to examine if there were any differences in demographic variables between the two groups. There were no significant differences in grade, F (1,172) = 2.1, p = 0.15, and gender, F (1,172) = 0.18, p = 0.67; however, a significant difference existed for race, F (1,172) = 4.35, p = 0.04 and age, F (1,172) = 5.33, p = 0.02.

Table 4-1

Descriptive Statistics of the Preliminary Sample for Gender, Race, Grade (n/%) and Age(M/SD)

	App-based (n=62)	Comparison (n=112)	Total (n=174)
Gender			
Female	32 (51.6)	54 (48.2)	86 (49.4)
Male	30 (48.4)	58 (51.8)	88 (50.6)
Race			
White	7 (11.3)	49 (43.8)	56 (32.2)
Black	47 (75.8)	38 (31.3)	85 (48.9)
Hispanic	0 (0)	11 (9.8)	11 (6.3)
Asian	1 (1.6)	10 (8.9)	11 (6.3)
Other	7 (11.3)	4 (3.6)	11 (6.3)
Grade			
4th	25 (40.3)	58 (51.8)	83 (47.7)
5th	37 (59.7)	54 (48.2)	91 (52.3)
Age			
Years Avg	10.6	10.3	10.4

Note. The numbers in parentheses indicate percentage.

Physical activity-related variables. The average time of the three physical education sessions was 39.39 minutes and 43 minutes for the app-based group and the comparison group, respectively. Since the class time difference was significant, F (1,172) = 329.25, $p < 0.001$, the percentage of time (instead of minutes) spent in sedentary

behavior, light physical activity and moderate-to-vigorous physical activity were used as physical activity outcome variables.

Table 4-2

Mean Minutes and Mean Percentage Time Spent in Each Type of Physical Activity in Physical Education

	App-based	**Comparison**
Sedentary % (min)	39.2 (15.3)	45.1 (19.5)
Light % (min)	28.3 (10.9)	26.9 (11.5)
MVPA % (min)	32.5 (12.9)	28.0 (12.0)

The ANCOVA with race as covariate indicated that there were no significant differences in the percentage of time spent in sedentary behavior, F (1,172) = 9.58, p = 0.07, η^2 =0.79, and light physical activity, F (1,172) = 1.32, p = 0.36, η^2 =0.38. However, difference in the percentage of time spent in moderate-to-vigorous physical activity was significant, favoring the app-based group, F (1,172) = 12.07, p = 0.04, η^2 = 0.80. Table 4-2 shows the mean minutes and the mean percentages of time spent in each intensity of physical activity.

Psychosocial variables. The data on children's beliefs was transformed to meet the assumption of normality. MANCOVA with race as covariate was conducted to investigate differences in children's self-efficacy, outcome expectancy, social support, and enjoyment. The alpha was set to 0.0125 for this analysis. The results indicated that there were no significant differences in children's beliefs between the app-based group

and the comparison group at baseline, F (1,168) = 2.11, p = 0.08, η^2 = 0.05. The mean scores of children's beliefs are presented in Table 4-3.

Table 4-3

Children's Belief Scores for the Preliminary App-based and Comparison Groups

	App-based (n=62)	**Comparison (n=112)**
Self-efficacy	5.27 (1.07)	5.35 (1.02)
Outcome expectancy	9.92 (1.77)	9.72 (1.94)
Social support	4.32 (0.97)	4.44 (0.86)
Enjoyment	3.90 (1.17)	4.12 (1.18)

Power analysis. Finally, a power analysis was conducted with the preliminary study's mean and standard deviation of percentage of time spent in moderate-to-vigorous physical activity. The results indicated that to obtain 80% of power, 75 participants are needed for each group.

Demographic Information for the Main Study

Demographic information for all participants in the main study is presented in Table 4-4. There were no significant differences between the app-based group and the comparison group in age F (1,155) = 0.78, p =.38, grade, F (1,155) = 0.31, p =.58 and gender, F (1,155) = 1.04, p = 0.31. However, there was a significant difference in children's race, F (1,155) = 5.40, p =0.02.

Table 4-4

Descriptive Statistics of the Sample for Gender, Race, Grade (n/%) and Age(M/SD)

	App-based (n=77)	Comparison (n=80)	Total (n=157)
Gender			
Female	39 (50.6)	34 (42.5)	73 (46.5)
Male	38 (49.4)	46 (57.5)	84 (53.5)
Race			
White	6 (7.8)	32 (40.0)	38 (24.2)
Black	54 (70.1)	25 (31.3)	79 (50.3)
Hispanic	2 (2.6)	0 (0)	2(1.3)
Asian	1 (1.3)	10 (12.5)	11 (7)
Other	14 (18.2)	13 (16.3)	27 (17.2)
Grade			
4th	41 (53.2)	39 (48.8)	80 (51)
5th	36 (46.8)	41 (51.2)	77 (49)
Age			
Years Avg	9.8 (.63)	9.7 (.66)	9.7 (.64)

Physical Education Class Time

Before reporting children' physical activity time, the class periods were noted. The mean class time for each physical education session at pre- and post-test are presented in Table 4-5 and Table 4-6. At the pre-test, the average class time was 40.6 and 40.9 minutes for the comparison group and the app-based group, respectively. This class time difference was not significant, F (1, 156) =0.12, p= 0.73.

Table 4-5

Mean Minutes of Each Physical Education Session at Pre-test (min)

Pre-test	**Session 1**	**Session 2**	**Session 3**	**Average**
App-based	37.7 (3.00)	40.8 (6.54)	47.8 (1.07)	40.9 (7.70)
Comparison	40.7 (1.70)	41.4 (7.14)	39.6 (4.96)	40.6 (.69)

Table 4-6

Mean Minutes of Each Physical Education Sessions at Post-test (min)

Post-test	**Session 4**	**Session 5**	**Session 6**	**Average**
App-based	47.2 (1.04)	38.9 (5.92)	34.8 (5.65)	39.7 (7.80)
Comparison	47.7 (2.52)	43.4 (2.36)	44.9 (2.93)	45.2 (1.08)

At the post-test, the average class time for the app-based school and the comparison school was significantly different, F (1, 156) = 40.3, $p < 0.01$. Since the

difference in the average class time between the groups was significantly, the percentages of time spent in different physical activity intensities were used as the outcome variables.

Preliminary Analyses for Outcome Variables

Preliminary analyses were conducted to examine if initial difference existed between the two groups for all outcome variables. For all analyses, race was set as the covariate. The percentage of time spent in sedentary behavior was not significantly different between the groups, F (1, 148) =3.89, p = 0.07, η^2 =0.19. However, significant differences existed between the app-based and the comparison groups in the percentage time spent in light physical activity, F (1, 148) =14.57, p = 0.03, η^2 = 0.82, and moderate-to-vigorous physical activity, F (1, 148) =5.49, p = 0.04, η^2 = 0.35. The pre-test percentages of time for each physical activity are presented in Table 4-8.

Initial analyses of internal consistency of the beliefs questionnaire indicated that Cronbach's alpha for outcome expectancy, social support, and enjoyment were slightly less than adequate. Thus, three items (e.g., item number 2,6,10) from outcome expectancy, one item (i.e., item 5) from social support, and one item (i.e., item 4) from enjoyment were removed from the original questionnaire to increase the reliability levels. The initial and adjusted Cronbach alphas are presented in Table 4-7.

Table 4-7

Internal Consistency of Each Belief

	Cronbach alpha	
	Unadjusted	**Adjusted**
Self-efficacy	0.71	0.71
Outcome Expectancy	0.63	0.70
Social Support	0.55	0.63
Enjoyment	0.58	0.67

In order to compare the initial differences in each belief between groups, MANCOVA with race as a covariate was conducted, which indicated no significant differences in all four beliefs, F (1, 150) =1.13, p = 0.35, η^2 = 0.03. Pre-test scores for the beliefs are presented in Table 4-9.

Changes in Children's Physical Activity Levels

Within group analysis. To test the first hypothesis that the app-based group would demonstrate a significant decrease in their sedentary behavior, and increases in their light and moderate-to-vigorous physical activity over time, a series of dependent t-tests were conducted. Contrary to our hypothesis, the children in the app-based group demonstrated an increase in their sedentary behavior by 14.8%, and decreases in their light and moderate-to-vigorous physical activity by 6.2% and 8.6%, respectively. These changes were all statistically significant: The increase in the percentage of time spent in

sedentary behavior, t (1,73) = 3.7, $p < 0.001$, the decreases in the percentages of time spent in both light, t (1,73) = 7.4, $p < 0.00$, and moderate-to-vigorous physical activity, t (1,73) = 8.3, $p < 0.001$.

Between group analysis. To test the second hypothesis, differences in the changes of the percentage time spent in different intensities of physical activities over time was compared. Analysis of covariance (ANCOVA) with race as a covariate results indicated that the app-based group (14.8%) had a significantly greater increased sedentary time than the comparison group (-2.6%), F (1, 154) = 110.6, $p < 0.001$, η^2 = 0.42.

Regarding the percentage of time spent in light physical activity, the percentage for the app-based group decreased (-6.2%) while it increased for the comparison group (4.2%) The difference between the two groups in light physical activity was significant, F (1, 154) = 97.7, $p < 0.001$, η^2= 0.39. In terms of the percentage of time spent in moderate-to-vigorous physical activity, children in both groups demonstrated a decrease; however, the decrease in the app-based group (-8.6%) was significantly greater than that of the comparison group (-1.6 %), F (1, 154) =31.4, p<.001, η^2 =0.17. The means and standard deviations for the pre- and post-test percentages of time spent on physical activity are presented in Table 4-8.

Table 4-8

Percentages of Time Spent in Different Physical Activity Intensities (%/min)

	App-based (N=77)	Comparison (N=80)
Sedentary		
Pre-test	36.9(15.0)	37.4(15.1)
Post-test	51.8(20.9)	34.7(15.8)
Light		
Pre-test	33.2(13.6)	30.6(12.4)
Post-test	27.0(11.2)	34.9(15.7)
MVPA		
Pre-test	29.9(12.4)	32.0 (12.9)
Post-test	21.3(9.0)	30.5 (13.7)

Note. Numbers in parentheses indicate minutes

Changes in Children's Psychosocial Beliefs

Within group analysis. To test the third hypothesis, which was to examine if children's beliefs would significantly increase over time within the app-based group, MANOVA with repeated measures were conducted. The findings revealed that the increases in all beliefs were not significant, F (1, 72) = 1.10, p = 0.37, η^2 = 0.06. The means and standard deviations of the belief scores are presented in Table 4-9.

Table 4-9

Pre- and Post-Test Scores of Children's Beliefs

	App-based			Comparison		
	Total	**Female (N=39)**	**Male (N=38)**	**Total**	**Female (N=34)**	**Male (N=46)**
Self - Efficacy						
Pre-test	5.1 (1.17)	5.2(1.21)	5.0(1.11)	5.0 (1.65)	4.9(1.80)	5.0(1.56)
Post-test	5.4 (1.10)	5.6(.64)	5.1(1.40)	5.2 (1.14)	5.3(.94)	5.1(1.28)
Outcome Expectancy						
Pre-test	7.3 (1.70)	7.1(2.05)	7.4(1.29)	7.1 (2.19)	6.5(2.57)	7.4(1.79)
Post-test	7.2 (1.97)	7.3(1.97)	7.0(1.98)	7.5 (1.71)	7.2(2.08)	7.7(1.36)
Social Support						
Pre-test	3.4 (.88)	3.6(.89)	3.2(.85)	3.4 (1.09)	3.1(1.39)	3.6(.78)
Post-test	3.6 (.82)	3.7(.75)	3.5(.89)	3.6 (.84)	3.6(.86)	3.6(.83)
Enjoyment						
Pre-test	2.8 (1.14)	2.5(1.25)	3.2(.95)	3.1 (1.24)	2.5(1.52)	3.5(.75)
Post-test	3.0 (1.23)	2.7(1.25)	3.3(1.18)	3.1 (1.18)	2.7(1.36)	3.4(.95)

Note. Numbers in the parentheses indicate standard deviation

Between group analysis. Fourth aim of this study was to examine if children's changes in beliefs would significantly differ between the app-based and the comparison groups. MANCOVA with race as the covariate was conducted and the findings revealed that race influenced the scores of all beliefs, F (1, 150) = 2.81, p = 0.03, η^2 = 0.07; however, there was no significant difference in changes of children's beliefs between the

app-based group and the comparison group. Adjusted means and standard deviations for each belief are shown in Table 4-10.

Table 4-10

Unadjusted and Adjusted Means of Children's Changes in Beliefs Scores

	Unadjusted*		**Adjusted****	
Beliefs	**App-based**	**Comparison**	**App-based**	**Comparison**
Self-efficacy	0.24 (1.56)	0.23 (1.6)	0.19 (0.18)	0.27(0.18)
Outcome Expectancy	-0.09 (1.79)	0.43 (2.16)	-0.08 (0.23)	0.42(0.23)
Social Support	0.16 (0.90)	0.2 (1.25)	0.19 (0.13)	0.17 (0.12)
Enjoyment	0.16 (1.47)	0.0 (1.34)	0.17 (0.16)	-0.01 (0.16)

Note. *Numbers in the parentheses indicate standard deviation; ** Numbers in the parentheses indicate standard errors.

Relationship among Children's Beliefs and Physical Activity

A series of linear regression for each group was conducted separately to predict children's physical activity level (i.e., percentage of time spent in moderate-to-vigorous physical activity) in physical education classes based on their pre- and post-test self-efficacy, outcome expectancy, social support, and enjoyment. The scores of each psychosocial belief were standardized since the scale of each belief had a different range. Outliers were excluded in the analyses using Mahalanobis Distance (i.e., > 18.22), which left 71 and 79 observations for the app-based group and the comparison group, respectively. For the regression analyses the "Enter" method was chosen. Means and

standard deviations for each belief in both groups are presented in Table 4-9. In the following, the relationship between children's physical activity and beliefs are presented in the order of 1) pre-test in the app-based group; 2) post-test in the app-based group; 3) pre-test in the comparison group; and 4) post-test in the comparison group. For each section correlation and regression analyses are presented.

Pre-test relationships in the app-based group. Bivariate correlations between all outcome variables are presented in Table 4-11. Children's outcome expectancy was significantly correlated with social support in the app-based group at pre-test, but none of the children's beliefs was significantly correlated to their moderate-to-vigorous physical activity.

Table 4-11

Correlations between Psychosocial Beliefs and MVPA Percentage for App-based Group at Pre-test

Variable	1	2	3	4	5
1. Self-efficacy		-.11	.17	.19	.06
2. Outcome expectancy			.32*	.07	-.09
3. Social Support				-.02	-.10
4. Enjoyment					.01
5. MVPA					

Note. * p <.01; MVPA: Moderate-to-vigorous physical activity

A summary of multiple regression analyses used to predict the percentage of time in moderate-to-vigorous physical activity is presented in Table 4-12. The percentage of time was predicted from the four psychosocial beliefs among children of the app-based

group. The results of the regression analyses indicated the four predictors explained 1.9 % of the variance in children's pre-test physical activity, however there was no significant regression equation found, $R^2 = 0.02$, F (4,66) = 0.31, $p = 0.87$.

Table 4-12

Summary of Simple Regression for Four Variables Predicting Children's MVPA Percentage in App-based Group at Pre-test

Variable	*B*	*SE B*	*β*	*t*	*p*
Self-efficacy	.008	.014	.078	.582	.56
Outcome Expectancy	-.005	.012	-.052	-.393	.70
Social Support	-.008	.011	-.094	-.712	.48
Enjoyment	-.002	.010	-.024	-.196	.85
R^2	.02				
F	0.31				

Note. MVPA: Moderate-to-vigorous physical activity; *B:* Unstandardized coefficient*; SE B:* Standard error of coefficient*; β:* standardized coefficient.

Post-test relationships in the app-based group. Bivariate correlations between all outcome variables at post-test are presented in Table 4-13. Children's self-efficacy was significantly related to outcome expectancy and social support at the post-test.

A summary of multiple regression analyses to predict the percentage of time spent in moderate-to-vigorous physical activity at post-test from the four psychosocial beliefs is presented in Table 4-14. The results of the regression analyses indicated the four predictors explained 6.1 % of the variance in children's post-test moderate-to-vigorous physical activity, however there was no significant regression equation found, $R^2 = 0.06$, F (4,66) = 1.07, $p = 0.38$.

Table 4-13

Correlations between Psychosocial Beliefs and the MVPA Percentage for App-based Group at Post-test

Variable	1	2	3	4	5
1. Self-efficacy		.47**	.26*	.08	.08
2. Outcome expectancy			.04	.05	-.06
3. Social Support				.18	-.07
4. Enjoyment					.16
5. MVPA					

Note. * p <.05, ** p <.001; MVPA: Moderate-to-vigorous physical activity; 5. Percentage time in moderate-to-vigorous physical activity.

Table 4-14

Summary of Simple Regression for Four Variables Predicting Children's MVPA Percentage in App-based Group at Post-test

Variable	*B*	*SE B*	*β*	*t*	*p*
Self-efficacy	.017	.014	.174	1.24	.218
Outcome Expectancy	-.014	.013	-.147	-1.082	.283
Social Support	-.015	.014	-.139	-1.107	.272
Enjoyment	.015	.010	.176	1.450	.152
R^2	.061				
F	1.073				

Note. *B:* Unstandardized coefficient*; SE B:* Standard error of coefficient*; β:* standardized coefficient.

Pre-test relationships in the comparison group. Bivariate correlations between all variables for the comparison group at pre-test are presented in Table 4-15. In this group, all predictor variables were significantly correlated to each other, and both social support and enjoyment were significantly associated with children's moderate-to-vigorous physical activity.

Table 4-15

Correlations between Psychosocial Beliefs and MVPA Percentage for the Comparison Group at pre-test

Variable	**1**	**2**	**3**	**4**	**5**
1. Self-efficacy		.72**	.57**	.40**	.09
2. Outcome expectancy			.55**	.47**	.10
3. Social Support				.52**	.29*
4. Enjoyment					.34*
5. MVPA					

Note. * p <.01, ** p <.001; MVPA: Moderate-to-vigorous physical activity; 5. Percentage time in moderate-to-vigorous physical activity.

In Table 4-16, a summary of regression analyses to predict children's percentage of time spent in moderate-to-vigorous physical activity at pre-test from the four psychosocial beliefs is presented. The results of the regression indicated the four predictors explained 15.5 % of the variance in the percentage of time spent in moderate-to-vigorous activity at pre-test in the comparison group, and the model was significant, R^2= 0.16, F (4, 74) =3.39, p < 0.05.

Table 4-16

Summary of Simple Regression for Variables Predicting Children's MVPA Percentage in Comparison Group at Pre-test

Variable	*B*	*SE B*	β	*t*	*p*
Self-efficacy	-.008	.016	-.083	-.512	.61
Outcome Expectancy	-.011	.015	-.122	-.756	.45
Social Support	.022	.013	.241	1.692	.10
Enjoyment	.028	.012	.308	2.379	.02*
R^2	.155				
F	3.39*				

Note. *B:* Unstandardized coefficient*; SE B:* Standard error of coefficient*; β:* standardized coefficient. * $p < .05$

Post-test relationships in comparison group. Bivariate correlations between all variables for the comparison group at post-test are presented in Table 4-17. A correlation analysis indicated that most of children's post-test beliefs were significantly correlated to each other. In addition, at post-test, enjoyment was the only variable that was significantly related to children's percentage of time spent in moderate-to-vigorous physical activity.

Table 4-17

Correlations between Psychosocial Beliefs and the MVPA Percentage for the Comparison Group at post-test

Variable	1	2	3	4	5
1. Self-efficacy		.31*	.28*	.11	-.11
2. Outcome expectancy			.45**	.45**	.08
3. Social Support				.45**	.05
4. Enjoyment					.27*
5. MVPA					

Note. * p <.01, ** p <.001; MVPA: Moderate-to-vigorous physical activity; and 5. Percentage time in moderate-to-vigorous physical activity.

Table 4-18

Summary of Simple Regression for Variables Predicting Children's MVPA Percentage in the Comparison Group at post-test

Variable	*B*	*SE B*	β	*t*	*p*
Self-efficacy	-.013	.012	-.127	-1.067	.29
Outcome Expectancy	-7.89^{e-5}	.016	-.001	-.005	.99
Social Support	-.006	.016	-.051	-.380	.71
Enjoyment	.03	.0163	.308	2.338	.02*
R^2	.094				
F	1.90				

Note. *B:* Unstandardized coefficient*; SE B:* Standard error of coefficient*; β:* standardized coefficient.

The four psychosocial beliefs were used to predict the percentage of time spent in moderate-to-vigorous physical activity during the post-test. The summary of this regression analysis is presented in Table 4-18. The results of the regression analyses indicated that the four predictors explained 9.4 % of the variance in the percentage of time spent in moderate-to-vigorous physical activity, but the model was not significant, $R^2 = 0.09$, $F\ (4, 73) = 1.89$, $p = 0.12$.

Chapter Five

Discussions

App-based Physical Education

More physical education teachers are integrating technology in their classes to effectively teach and instruct students. In general, iPads and subject-specific mobile applications are becoming popular as they facilitate children's learning by keeping their attention and interest longer. These devices provide various practices incorporating games using the concepts that need to be learned (Aivaliotis-Martinez, 2013; Pyle & Esslinger, 2014). Therefore, it is natural to integrate technology in physical education classes, as it has always been challenging to manage students in a large gym space where children are inclined to move around freely.

As physical education teachers are facing challenges when instructing children to be physically active to the degree the national guidelines recommend (i.e., engagement in moderate-to-vigorous physical activity for at least 50% of the class period), it is essential to explore whether technology-integrated physical education would encourage children to be more active in a 50 minute-physical education class. The app-based classes, in which a teacher uses apps via iPad to effectively instruct and manage students, rely on children's savvy and interest in technology to gauge children's attention and increase their enjoyment of movement.

For the current study, the effectiveness of app-based physical education classes versus traditional classes was evaluated by conducting pre- and post-tests of children's sedentary behavior, light physical activity, and moderate-to-vigorous physical activity as

well as their psychosocial beliefs during physical education classes. In the app-based group, various types of sport- and exercise-related apps were used to motivate children to learn new skills, ease their understanding of the principles and rules of the movement to be learned, at the same time facilitate teacher's management of the class. In the comparison group, similar content was taught in a traditional way and technology usage was limited. Children were asked to wear accelerometers during the classes to track their time spent in sedentary, light, and moderate-to-vigorous physical activity. To examine children's psychosocial beliefs in physical activity, their self-efficacy, outcome expectancy, social support, and enjoyment were measured at pre- and post-tests.

In general, children's time spent in moderate-to-vigorous physical activity did not meet the recommended level of at least 50% of physical education class time for both groups. In terms of children's belief, the reliability of belief questionnaire turned out to be a moderate level, because even after dropping some items the internal consistencies of social support and enjoyment were still below the standard level of 0.70. Preliminary analyses of all demographic variables except race indicated that there were no differences between the two groups. All initial beliefs were not significantly different; however, the initial light and moderate-to-vigorous physical activity levels were significantly different between the groups. The children in the app-based group spent higher percentage of time in pre-test light physical activity while those in the comparison group spent higher percentage of time in moderate-to-vigorous physical activity.

Children's Physical Activity Levels

During the post-test sessions of physical education classes, children in the app-based group averaged 9 minutes of moderate-to-vigorous physical activity during 39.7 minutes of physical education class, while children in the comparison group averaged 13.7 minutes of moderate-to-vigorous physical activity during 45.2 minutes of class. Children in the app-based and the comparison groups spent approximately 21% and 31%, respectively of the class time in moderate-to-vigorous physical activity at post-test. Both of these percentages fall far shorter than what is recommended, namely 50% of class time to be spent in moderate-to-vigorous physical activity. Further, the minutes children spent in moderate-to-vigorous physical activity is not close to the 60 minutes per day of physical activity recommended. This implies that students must engaged in moderate-to-vigorous physical activity during recess and outside of school.

Physical activity levels of children in the app-based group decreased when apps were integrated into three sessions of physical education classes. Furthermore, this drop in children's physical activity level was significantly lower than the change in physical activity levels of children in the comparison group. In terms of the percentage of time spent in moderate-to-vigorous physical activity, changes in the percentage were negative for both the app-based and the comparison groups, with the app-based group demonstrating a steeper decline. Speaking of the changes in the percentage of time spent in light physical activity, students in the app-based group showed similar patterns to their moderate-to-vigorous physical activity in that they demonstrated a decrease in light physical activity by 6.2% from pre-to post-test. Meanwhile, the comparison group

showed an increase in light physical activity by 4.2%. All these findings are contradictory to our first two hypotheses that children in the app-based group will be more active both within and between groups, which suggests that the app-integrated sessions may not be as effective in increasing children's physical activities short term. Although contradictory to our hypothesis, similar finding has been reported in another study (Sun, 2012; Zhu & Dragon, 2016). Zhu and Dragon (2016) examined the effect of app-based physical education on 50 sixth graders' physical activity and situational interest, reporting that during the five app-integrated (iPads) sessions, children demonstrated significantly lower situational interest, objectively measured moderate-to-vigorous physical activity, and step counts compared to their counterparts in the comparison group. In this study, each student was distributed an iPad loaded with apps to follow instructions for activities offered in classes, and Zhu and Dragon (2016) attributed their findings to the fact that the children were experiencing a learning curve.

The findings of this study also reflect that students in the app-based group could have been undergoing the same phenomenon; a learning curve during the app-based sessions (Gao et al., 2011; Zhu & Dragon, 2016). The learning curve demonstrates the delay in time before the actual learning effect takes place, and the decrease in children's activity levels indicates that children may need a minimum of time before they get used to the setting. Innovative technology may be successful in gauging children's attention and interest immediately, but for the children to benefit from the app-based sessions, both teachers and children may need to be accustomed to the new technology used in the lessons. Therefore, for the future studies, the effect of app-based physical education

classes will need to be assessed once the students are comfortable with the new delivery of materials.

Other potential reason for such decline in children's physical activity levels may be due to the make-up of children in the app-based group. As 70% of children were black, originally from East Africa, activities that were offered in the app-based classes might not have had the similar effect as they would to the children in the comparison group whom were mostly white and African American. For example, many of the children from East African culture were having a difficult time in understanding the instructions about movements and games in class that they could not have had the full grasp of the activities offered in the class. This could have resulted in them not fully benefiting from neither the activities nor app-based setting.

In terms of sedentary behavior, the results indicate that students in the app-based group were more sedentary at post-test than they were at pre-test, which also explains the decline in the percentage of time spent in light and moderate-to-vigorous physical activity. The amount of time spent in moderate-to-vigorous physical activity in physical education can fluctuate depending on instructional time, transitional time between activities, and lesson content (Chen, Sun, Zhu, & Ennis, 2012). We speculate that the increase in the teacher's instruction, and transition time played a role in the increase of children's sedentary time. For example, teachers in the app-based group had to explain some basic rules about using the apps and what were expected of students. In addition, as playing music though apps were used for indicating transitions between activities,

pausing and replaying music created some lag time when teachers wanted to give additional instruction or feedback.

Children's Psychosocial Beliefs

Two of the aims in this study were to explore the effects of the app-based physical education classes on children's psychosocial variables. The variables were self-efficacy, outcome expectancy, social support, and enjoyment, which were measured at pre- and post-tests.

Self-efficacy. There was a slight change in scores from pre- to post-tests for children's self-efficacy for both the app-based and comparison groups. The adjusted changes in self-efficacy scores were higher in the comparison group, but the differences in the changes of score between the groups was not significant. The results of the present study are contradictory to our hypotheses, and inconsistent with other studies' findings suggesting technology-integrated physical activity has a positive influence on children's self-efficacy (Dos Santos, Bredehoft, Gonzalez, & Montgomery, 2016; Gao et al., 2012; Litman, 2015: Melton et al., 2015: Watterson, 2012). For example, these studies investigated the effects of various types of technology (e.g., Dance Dance Revolution [DDR], active video games, or prototype apps) in family or school settings. One of the studies by Gao et al. (2012) examined the effects of school-based 30-minute interactive dance games (e.g., DDR), which was implemented three times a week for nine months, finding that the DDR program in school had significant influence on children's self-efficacy as well as their physical activity level. In other studies (Litman, 2015; Melton et al., 2015), adult participants were asked to individually use fitness or exercise-based app

to promote physical activity and physical activity-related beliefs. This study also reported increase participants' self-efficacy.

A possible reason for such inconsistency with the findings of other studies may be the lack of direct physical activity prompt from the apps used in this study. Unlike the exercise apps and DDR which directly encourage people to be active, the apps used mostly by the teachers in this study were mainly for the management purpose (e.g., Stop watch, Timer, Scoreboard, etc.). Additionally, Coach's Eye, the video recording app that were supposed to be employed to provide children with tailored feedback were rarely used due to some management issues in classes. As adequate use of Coach's Eye app was critical in assisting children to gain self-efficacy in producing to-be learned movements, it may be no surprise to not see a significant increase in children's self-efficacy. In addition, the fact that children did not have access to iPads themselves, thus no control over using apps deemed to have also contributed to little changes in children's self-efficacy.

Race may be another potential explanation. The adjusted mean for changes in self-efficacy in the app-based group was lower than that of the comparison group, supporting previous literature that has reported lower self-efficacy among African American and Hispanic children compared to their white counterparts (Fahlman, Hall, & Gutuskey, 2015). Research in the last decade provides support for the notion that self-efficacy is related to physical activity behavior in minority population (Gao, 2012; Hausenblas et al., 2002; Martin & McCaughtry, 2008b). The fact that children in the app-based group was largely African American, and that their physical activity levels

decreased over time explains the little improvement in children's belief in their capability to be physical activity.

Outcome expectancy. The changes of children's outcome expectancy scores did not vary significantly between the app-based group and the comparison group. While the children in the app-based group maintained their scores from pre- to post-tests, the scores of children in the comparison group increased. This finding is contrary to this study's hypothesis, but it is consistent with the results from a study done by Gao et al. (2012). In this study, the researchers used DDR, and found that change in scores of children in the experiment group was not significantly different from that of children in the comparison group. It is possible that, although many advantages exist for using apps for educational tools, the apps used in this study tapped little on the benefits of physical activity to elicit enhancement in children's outcome expectancy (Gao et al., 2012).

As mentioned in the literature review, outcome expectancy has three forms, which were physical, social, and self-evaluative expectations. For the questionnaire that were used in this study, there were only physical and social expectations. Tapping into these different forms of outcome expectancy, app-integrated instruction during the class seemed to have had little impact on the two expectations. Some of the outcome expectancy questionnaire items asked children whether being active in physical education classes would make them better in sports, be healthy, and control weight, however, the apps relating to these contents were not extensively used in the classes. We speculate that this might be another potential reason for little improvement in the outcome expectancy.

Social support. Only small improvements of social support were found in both conditions. Although it was hypothesized that the increase in social support be significantly greater for the app-based group than for the comparison group, the results were not significant. The findings from this study only partially support our hypothesis, and the results from a previous study (Gao et al., 2012). It is possible that the app used in the physical education sessions did not have many features supporting exercise or games played in the class. As mentioned in the discussion of self-efficacy, children did not have much chance to use Coach's Eye, video recording app that were intended to play as the main app to contribute in children's improvement in social support. If children had more chance of using the app to get feedback about their movement in groups, it might have had a greater positive impact on their perceived social support. Another reason could be that teachers were using the apps mostly for the purpose of class management, such as shifting from activity stations and refocusing children's attention. The physical educators' endeavor to efficiently manage class can be considered as being supportive of children being active, because it gives children more time to move, as opposed to being sedentary or standing. However, for the children to be cognizant of the encouragement and support they receive, the message needs be delivered in more explicit way.

A few studies have agreed to the notion that social support is an important correlate of children's physical activity (Gao, et al., 2012; van der Horst, et al., 2007), and that it may be an essential factor for the minority population (Gao, 2012; Bean et al., 2012). In his study, Gao (2012) examined the role of psychosocial beliefs in Hispanic children's objectively-assessed daily physical activity level, finding that their social

support and self-efficacy were significantly related to children's physical activity level. Likewise, Bean and his colleagues (2012) suggested that social support and self-efficacy need to be taken into consideration when promoting physical activity among African American girls.

Enjoyment. There was a slight increase in the enjoyment score for the app-based group, while children from the comparison group maintained their scores. The difference in the change of scores for enjoyment between the groups was not significant. These findings do not support our hypothesis that there will be significant differences within and between the groups, which may suggest that although the app-based instruction elicited enjoyment in children, it was not strong enough to translate into enjoyment in physical activity to the desirable extent. We also speculate that if the intervention period was longer, the difference in the changes of score between the groups could have reached a significant level. Our findings are contrary to the results of numerous previous studies that examined the impact of technology integrated physical activity programs on children's enjoyment (Duncan & Dick, 2012; Gao et al., 2014; Gao, Podlog et al., 2013; Gao, Zhang et al., 2013; Gao et al., 2012). In most of these studies, the researchers investigated the effect of active video games (exergaming) on students' enjoyment and revealed that students in the technology group demonstrated greater enjoyment compared to those in the traditional physical activity groups. One of the reasons for the discrepancy between findings of this study and those of previous studies may be due to the difference in the platform of technology. While active video games encouraged students to be

physically active, the apps used in this study did not directly prompt such physical movement themselves.

Relationships among Children's Physical Activity and Beliefs

The relationships between psychosocial beliefs and children's percentage of time on moderate-to-vigorous physical activity were examined in each group. The results did not support for our hypothesis. In the app-based group, none of the pre- and post-test psychosocial variables significantly predicted children's pre- and post-test percentage of time spent in moderate-to-vigorous physical activity. In addition, the four-belief model explained only 2% and 6% of the variances in children's pre- and post-test moderate-to-vigorous physical activities, respectively. For the comparison group, children's enjoyment significantly predicted children's pre- and post-test percentages of time spent in moderate-to-vigorous physical activity. Moreover, the four belief model explained 16% and 9% of variances in children's pre- and post-test moderate-to-vigorous physical activities, respectively.

The beliefs explained a small portion of variances in children's moderate-to-vigorous physical activity for both groups, which is in line with existing literature. Previous studies have documented that physical activity measurements act as a moderating factor, showing small variances when assessed with objective measures. When objective measures were used to assess children's physical activity, the Social Cognitive Theory model explained about 8% of the physical activity variance (Gao, 2012; Strauss et al., 2001; Ramirez et al., 2011), which is echoed by findings of this study.

For the app-based group, none of the beliefs significantly predicted children's percentage of time spent in moderate-to-vigorous physical activity at post-test. We speculate that questionnaires reliability could have been one of the reasons. In this study, questionnaires for all beliefs except self-efficacy were not ideal as tested by Cronbach alphas, especially for social support and enjoyment. The questionnaires themselves have been reported as valid and reliable measures; however, the time the questionnaires were conducted might not have been the best time to assess children's beliefs. Especially for children in the app-based group, physical education classes were scheduled as the last one of the day, and when the assessment were conducted toward the end of the class, children were anxious to leave the class. Although the research assistant emphasized the importance of answering questionnaires truthfully and seriously, some children could have been not motivated to comply at the time of the day, which could have impacted the reliability of some questionnaires.

Another potential reason for the model not being significant in predicting children's physical activity may be due to some confounding factors that were not measured, which could have countered positive influences of app-based classes on children's beliefs, hence on their physical activity as well. For instance, due to children's transition to the technology implemented classes, they could have experienced confusion or frustration at the time of assessing their beliefs. These are emotions that children usually experience during the adjustment period, which could have hindered children's enjoyment.

Unlike the findings of other literature, self-efficacy was not a significant predictor of children's physical activity in both groups. We speculate that the reason was because of the type of self-efficacy we measured. For the minority children, it has been documented that different forms of self-efficacy might play a role in predicting physical activity. The questionnaire used in this study to assess self-efficacy measured task self-efficacy for the most part, yet many researchers have found that other types of self-efficacy are associated with physical activity of minority children (Martin & McCaughtry, 2008). For example, barrier self-efficacy predicted physical activity in Arab American adolescents (Martin, McCauhtry, & Shen, 2008). In addition, another study by Dzewaltowski et al. (2007) provided evidence that proxy efficacy (support-seeking efficacy) was another important type for predicting minority children's physical activity. Similarly, in their study of predominantly African American children, Saunders et al. (1997) found that children who reported higher proxy self-efficacy in their physical activity involvement were more likely to engage in vigorous physical activity. Given the high percentage of African American children in our app-based group, we speculate task efficacy may not have been effective in predicting their physical activity compared to the comparison group. It did not associate as strongly with these under-represented children's moderate-to-vigorous physical activity.

Study Strengths

To our knowledge, the present study is the first of its type to examine the impact of app-integrated physical education on children's psychosocial variables. A major strength of this study is that it is theory-based. In addition, while many studies have

explored the effect of technology on psychosocial beliefs under the framework of Social Cognitive Theory, few have investigated the effect of app integration in physical education settings. Physical education class is an important setting in which children have opportunities to be physically active. Based on the findings of this study, strategies to promote children's moderate-to-vigorous physical activity are warranted. Another major asset of this study is that we used objectively-assessed physical activity outcome variables as measured by accelerometers, providing a rich set of data with improved interpretations on physical activity intensity. A further strength of this study would be the use of innovative technology as an intervention tool, as it is cutting edge and has important implications for current physical educators. It is important to note that the present study targeted minority children. These minority students are highly at risk for childhood obesity and characterized by lower physical activity levels than their white counterparts, thus the findings of this study can be helpful to this population. The final asset of this study is that the intervention and the comparison groups had a nearly equal number of participants, consisted both 4^{th} and 5^{th} graders, and included both males and females.

Study Limitations

Several limitations with this study should be taken into consideration when interpreting and building upon the findings. First, as many school-based studies address, the study sample was a convenient sample. Children were recruited from only two schools, and school served as a recruitment unit, which hampers the generalizability of the findings compared to studies with a random recruitment and assignment.

Additionally, the samples from the two schools had an uneven distribution of racial backgrounds. Specifically, the app-based school had a higher percentage of African American than any other race. As race and ethnicity are moderating factors in explaining children's physical activity levels, they should be taken into consideration.

Second limitation of this study would be the types of apps used and the period of app-integration. The reason for increasing popularity of using apps in physical education classes would be because of the innovative and distinctive features the apps have to offer to the class that traditional classes are limited to. Thus, to see the true effect of app-based physical education classes, it may have been more meaningful to have used apps that do serve such features. Unfortunately, the apps that were mostly used in this study were music player, scoreboard and timer apps that can easily be replaced with physical CD players, scoreboards, and timers. Therefore, for future studies, researchers need to be careful in selecting the appropriate apps that not only facilitate the management and instruction in classes, but also that are unique in developing children's motor skills and improving their beliefs on physical activity. In terms of intervention period, we speculate that the study could have yielded better results with a longer intervention before taking a post-test. Given the short period of intervention duration, it is possible that the post-test results only display short term effect of app integration in physical education. In this study, children and teachers could have needed little more time to adjust to the devices before fully appreciating their positive effects.

Another limitation of this study would be some possible confounding variables such as lesson materials and teaching style. Due to some logistical issues, the two schools

in this study could not employ an identical curriculum in physical education. It would have been ideal to use the same lesson materials for both groups to increase the internal validity of this study; however, each school had its own lesson plans for its physical education classes. Although the activities and games offered during classes at both school deemed comparable, it is still possible that slight difference in the same activities could have different influence on children's beliefs and physical activity. Likewise, other teacher-related covariates need to be considered. For example, while two teachers instructing the children participating in the comparison group, children from the intervention group were instructed by four different teachers due to condensed physical education schedules in this group. This could allow much student variations even within the app-based group. Having different teachers instructing each group could also mean children were exposed to different teaching style, which could also impact students' behaviors and thoughts. Therefore, in the future studies, it would be necessary to have same teacher(s) and curricula employed to intervention and comparison groups.

Finally, the reliability of the belief questionnaires did not turn out to be ideal. The internal consistencies of questionnaires on outcome expectancy, social support, and enjoyment were still around or below 0.7 even after items from some questionnaires were removed. Thus, consideration need to be put into as the results are interpreted. In the future, it might be prudent to have multiple assessments of children's beliefs to avoid such possible measurement issue.

Practical Implications

It is recommended that in an app-based physical education classes, children themselves have more opportunities to engage in group activities using iPads and apps to benefit more from the features such as video playback to receive feedback on their own movements. Such tailored feedback via apps in peer groups is a strategic means to provide support and build self-confidence in children. True technology integration may have its limitations for the teacher-centered physical education class. Technology can provide valuable feedback and meet individual student's needs; however, the real power of technology is in the student-centered model which consists of instructional techniques such as collaboration, differentiated instruction, and valid assessments (Biesinger & Crippen, 2010).

When teachers decide to integrate apps to their physical education lessons, the design of app integration should be tailored to their students' needs, which are different from classes to classes. In this study, teachers from the app-based group, which consisted of larger percentage of minority children than the comparison group, mentioned that it is much easier to instruct children with music when shifting from one activities to the other because of some children's language barrier following instructions. This indicates that children of different demographics may have distinct characteristics related to behavioral modifications such as physical activity. Therefore, the make-up and characteristics of the children in the class need to be taken into consideration upon the usage and integration of mobile apps for the app integration component in physical education to be successful in motivating children to enhance their beliefs and physical activity levels.

Finally, as mentioned in limitations, it is recommended that technology integration in class be implemented over a longer course of time. Children in the app-based classes seemed to be enjoying some features of apps (e.g., playing music), however the technology integration in this trial did not come to its full potential. It is recommended that teachers receive more training if possible, to increase their competence in using the mobile technology. As there is a technology gap between generations, it is important that the teachers have confidence and be comfortable with using the apps. In his study on app-supplemented middle school physical education, Watterson (2012) discussed how teachers' perceived competence with using the technology constantly changed and that they expressed a desire for more in-service learning time with certain app features.

Directions for Future Studies

Research examining the effectiveness of mobile apps on increasing children's physical activity and improving psychosocial beliefs in physical education setting is still in its nascent stage. As such, similar studies with a longer intervention period should be conducted and evaluated with other populations of varying demographic characteristics. As children's interest in technology may wither over the course of time, it will also be important to do follow-up studies after the intervention to examine any sustainability of the app-integration effects.

When integrating such innovative technology into physical education setting, examining the mediating effects of children's psychosocial beliefs on other beliefs will be essential, as these beliefs are reported to not only directly predict children's physical

activity, but also to influence other beliefs in changing physical activity behavior. For example, in a recent study, Lewis, Williams, Frayeh, and Marcus (2016) revealed that enjoyment influences self-efficacy in engaging regular physical activity in low active adults. In fact, children's enjoyment was the only predictor in explaining their moderate-to-vigorous physical activity in the comparison group. It could be possible that children's engagement in moderate-to-vigorous physical activity was the mediating effect of their self-efficacy impacted by their enjoyment, just as the findings from Lewis et al. (2016) study. Therefore, in the future, it will be important to investigate whether this mediating effect would also manifest in the app-based physical education setting.

Lastly, future studies should examine all subconstructs of self-efficacy and outcome expectancy, if possible, as each subconstruct associate differently with children's physical activity, often moderated by demographic variables such as ethnicity. It is likely that gender differences exist in some of the psychosocial variables, as males and females respond differently to technology. Thus, more studies are warranted on investigating gender effects on the relationship between Social Cognitive Theory constructs and physical activity in app-integrated physical education.

Conclusions

This present project found short-term technology integration in physical education classes, especially with mobile apps and iPad, had little effect on increasing elementary children's physical activity and improving their psychosocial beliefs. A longer intervention period may be needed to witness true effect of technology in promoting children's physical activity in physical education as certain amount of time is needed for

both children and physical educators to feel competent in using technology. In this study, mobile apps served more as supplementary tools to facilitate teachers' management of the class rather than as tools for instruction, assessments, and motor skill development. In the long term, however, mobile apps should be integrated in a way that students have more autonomy in using the devices to assist their motor skill learning, which would possibly lead to promotion of physical activity by enhancing certain psychological beliefs such as self-efficacy and enjoyment in physical activity.

Chapter Six

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Chapter Seven

Appendices

Appendix A. IRB Form

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Human Research Protection Program
Office of the Vice President for Research

D528 Mayo Memorial Building
420 Delaware Street S.E.
MMC 820
Minneapolis, MN 55455

Office: 612-626-5654
Fax: 612-626-6061
E-mail: irb@umn.edu or ibc@umn.edu
Website: http://research.umn.edu/subjects/

May 2, 2016

June Lee

RE: "Children's Physical Activity and Psychosocial Beliefs in Mobile Application-based Physical Education"
IRB Code Number: **1603P85518**

Dear Ms. Lee

The Institutional Review Board (IRB) received your response to its stipulations. Since this information satisfies the federal criteria for approval at 45CFR46.111 and the requirements set by the IRB, final approval for the project is noted in our files. Upon receipt of this letter, you may begin your research.

IRB approval of this study includes the parent consent form and assent form received April 18, 2016.

The IRB determined that children could be included in this research under 45CFR46.404; research not involving greater than minimal risk.

The IRB approved a waiver of documentation of parent consent in accord with 45 CFR 46.117 (c) (2) as the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context. Parents will be given a copy of the consent form for their records.

The IRB would like to stress that subjects who go through the consent process are considered enrolled participants and are counted toward the total number of subjects, even if they have no further participation in the study. Please keep this in mind when calculating the number of subjects you request. This study is currently approved for 160

subjects. If you desire an increase in the number of approved subjects, you will need to make a formal request to the IRB.

On April 1, 2016 the IRB approved the referenced study through March 31, 2017 inclusive.

The Assurance of Compliance number is FWA00000312 (Fairview Health Systems Research
FWA00000325, Gillette Children's Specialty Healthcare FWA00004003). Research projects are subject to continuing review and renewal. You will receive a report form two months before the expiration date. If you would like us to send certification of approval to a funding agency, please tell us the name and address of your contact person at the agency.

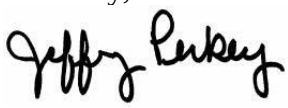
As Principal Investigator of this project, you are required by federal regulations to:
*Inform the IRB of any proposed changes in your research that will affect human subjects, changes should not be initiated until written IRB approval is received.
*Report to the IRB subject complaints and unanticipated problems involving risks to subjects or others as they occur.
*Inform the IRB immediately of results of inspections by any external regulatory agency (i.e. FDA).
*Respond to notices for continuing review prior to the study's expiration
date. *Cooperate with post-approval monitoring activities.

Notify the IRB when you intend to close this study by submitting the Study Inactivation Request Form.

Information on the IRB process is available in the form of a guide for researchers entitled, What Every Researcher Needs to Know, found at
http://www.research.umn.edu/irb/WERNK/index.cfm

The IRB wishes you success with this research. If you have questions, please call the IRB office at 612626-5654.

Sincerely,



Jeffery Perkey, MLS, CIP
Research Compliance Supervisor
JP/bw

CC: Zan Gao, Zachary Pope

Appendix B.
Questionnaire

Demographics

1	Name: _____ Date of Birth: ____/____/____. First Last month day year
2	What grade are you in? ☐ 4th grade ☐ 5th grade
3	What is your gender? ☐ Female (Girl) ☐ Male (Boy)
4	How old are you?_____Years (enter the number)
5	Race (Check one): White-American ☐ African-American ☐ Hispanic-American ☐ Asian-American ☐ Other ☐

	Self-efficacy		
	With regard to the activity in the physical education class today, I have confidence in …	**Yes**	**No**
	my ability to doing well in this activity.	**Yes**	**No**
	my ability to learn skills well in this activity.	**Yes**	**No**
	my performance in this activity.	**Yes**	**No**
	my knowledge needed to do well in this activity.	**Yes**	**No**
	my success in this activity if I exert enough effort.	**Yes**	**No**
	my ability to handle the anxiety related to this activity	**Yes**	**No**

	Belief	**Yes**	**No**

	If I were to be physically active in physical education (PE) class,		
	…..it would get or keep me in shape.	**Yes**	**No**
	…..it would be boring.	**Yes**	**No**
	…..it would make me better in sports.	**Yes**	**No**
	…..it would be fun.	**Yes**	**No**
	…..it would help me be healthy.	**Yes**	**No**
	…..it would make me get hurt.	**Yes**	**No**
	…..it would help me control my weight.	**Yes**	**No**
	…..it would make me embarrassed in front of others.	**Yes**	**No**
	…..it would give me energy.	**Yes**	**No**
	…..it would make me tired.	**Yes**	**No**
	…..it would help me make new friends.	**Yes**	**No**
	…..it would help me spend more time with my friends.	**Yes**	**No**

	Social Support	**Yes**	**No**
	When participating in physical education (PE) class…		
	Does you PE teacher talk about exercise in lessons?	**Yes**	**No**
	Does you PE teacher organize or play games with you?	**Yes**	**No**
	Does you PE teacher tell you to exercise or play sports?	**Yes**	**No**
	Do your friends exercise or play sports with you in PE?	**Yes**	**No**
	Do you ask your friends to play with you in PE?	**Yes**	**No**

	Enjoyment	**Yes**	**No**
	When participating in physical education (PE) class…		
	I have more fun doing PE than doing other things.	**Yes**	**No**
	Doing PE is the thing I like to do best.	**Yes**	**No**
	I wish I could do more PE than I get chance to.	**Yes**	**No**
	I usually prefer to watch rather than be physically active in PE.	**Yes**	**No**
	I really like doing PE at school.	**Yes**	**No**

Appendix C.

Sample Curriculum for App-based Physical Education Class

Time	Content	Mobile Applications
5 min	Warm-Up: Walk around the gym	
7 min	Muscular Strength Fitness : Push-ups, Sit-ups, Jumping Jack, Squats, Lunges	"Educreation"
8 min	Cardiorespiratory Fitness : Jog and Walk around the gym	"iTunes", "StopWatch", "Interval Timer"
15 min	Learning a Sport Skill: e.g., football catch and throw	"Coach's Eye"
10 min	Playing mini football games	"Team Shake", "ScoreBoard"
5 min	Wrap Up	

Sample Curriculum for Traditional Physical Education Class

Time	Content	Games and equipment
5 min	Warm-Up	Stretching
10 min	Enhancing Cardio Fitness: relay running	Footballs/" Nemo and the Shark"
15 min	Learning a Sport Skill: e.g., Football catch and throw	Footballs and cones
15 min	More of skill learning: e.g., Catch while you run	"Ice Fisher"
5 min	Wrap Up	

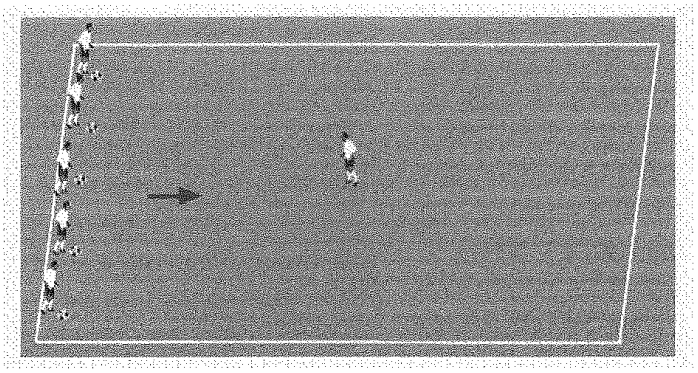
Appendix D.

Examples of Lesson Plans for the Comparison Group

<table>
<tr><td>Objectives:
1. Psychomotor: The students will perform proper soccer dribbling, passing, trapping and shooting technique.
2. Cognitive: The students will be able to describe how to dribble, pass, trap and strike the soccer ball.
3. Affective: Students will demonstrate cooperation, and safety for themselves and their classmates.
<u>I Can Statements:</u>
o I can find and stay in self-space.
o I can do a sole trap to control the ball.
o I can dribble a ball with control while changing directions.
o I can describe how to dribble, pass, trap and strike the soccer ball
o I can pass to a partner in an open space
o I can dribble around a stationary object without losing control of the ball.</td><td>Standards: NASPE 2004 – 1,2,3,5,6 Revised 1,2,3,4,5</td></tr>
<tr><td colspan="2">Previous Experience:
Students may have obtained previous soccer skills, knowledge and experience during elementary school. Some students may have additional knowledge / experience from playing or watching soccer. It's possible that some students may have no previous knowledge or experience with soccer.</td><td>Equipment Needs/Safety:
- Box/labels – 1 per student
- Music
- Cones
- Gator/Soccer balls
- Whistle
- Pins</td></tr>
</table>

Time:		Teaching hints and cues:
3-5 min	**Entry, Warm-up, Anticipatory Set:** 1. As students enter, teacher will immediately give students a box/label and will jog while music plays. 2. Students will pair and share when the music stops. 3. Repeat as music starts.	Students read calories on the label and then switch labels.
5-10 min	**Warm-up Activity** – Game – ***"Who let the dogs out"*** 1. Students will play tag game. 2. Music "Who let the dogs out"	
3-5 min	**Skill Activity**: Individual Dribbling 1. Students will utilized gym space and dribble around stationary objects (cones, noodles) while maintaining control of the ball.	***Small taps***, keep ball close & in control.
5-6 min	**Skill Activity**: Partner Passing 1. Student will play "gate" passing game. ▪ Sets of cones (gates) will be set up throughout the gym. ▪ Each pair of players attempts to make as many passes to each other (through the gates) as possible in 60 seconds. ▪ Players cannot pass through the same gate on consecutive passes. ▪ Challenge the players to improve on their previous score. X X Δ ↓ Δ Δ ↑ Δ X X	
6-10 min	**Skill Activity**: Sharks & Minnows ♦ Boundaries will be set at the discretion of the teacher. ♦ There are no goals or goalies. ♦ Two students will be designated as sharks and will start in the middle of the field/gym. ♦ Each minnow will have a ball at start at one end of the field/gym. ♦ On go/whistle minnows must get to the other end without losing possession of their ball. ♦ Sharks try to steal minnow's ball and kick it out of the defined area. ♦ If minnow has ball kick out by a shark. He/she becomes a shark. ♦ Play continues until no minnows are left. ♦ Soccer dribbling must be used.	

10-15 min



Skill Activity: Soccer Knock Down:

Game:

- 8 Soccer balls start on each side (can add more)
- Students can only kick the soccer balls
- Students cannot go into the end zone where equipment is (unless to retrieve a ball).
- Students cannot use hands unless retrieving a soccer ball.
- If equipment is knocked down, it stays down.
- The first team to knock down all the equipment wins.

Equipment

X X X X X X X

O O O O O O O O

Center Line

O O O O O O O O

X X X X X X X

Equipment

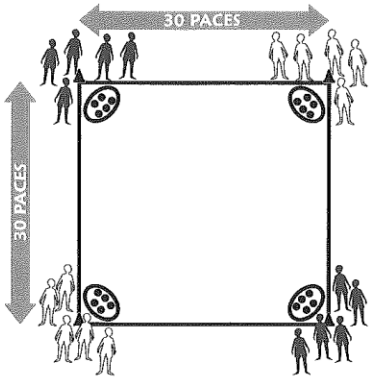
5 min	Closure: Recap Objectives. Bones of the week. Vertebrae & Ribs	
Reflections:		

SPARK™ ACTIVITY

SOCCER HOOPLA

Ready...

- 4 cones (for boundaries)
- 1 ball per student
- 4 hoops



Set...

- Create large square (30X30 paces) activity area.
- Place 1 hoop at each corner.
- Form 4 groups; 1 group per corner.
- Distribute soccer balls evenly among groups; place balls in hoops.

GO!

1. The object is to collect soccer balls from other hoops and dribble them to your home hoop.
2. On signal, run to another hoop, take 1 ball only, and dribble it to your home hoop.
3. Visit as many hoops as possible.
4. On signal, we'll see which group collects the most balls.
5. *(Distribute balls evenly among hoops, and play again.)*

CHALLENGES

- How many balls can your group dribble home before the stop signal?
- Can you dribble without staring at the ball?

CUES

- Keep the ball close when you dribble.
- Head up; look for open space; watch for others.
- When dribbling, use the inside and the outside of your feet.

GRADES 3-6

SOCCER

15

SPARK™ ACTIVITY

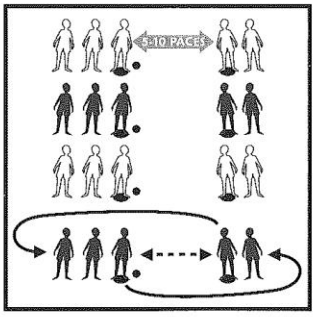
TRAP, PASS, AND FOLLOW

Ready...

- 1 ball per 4-5 students
- 2 spot markers per group of 4-5 students

Set...

- Groups of 4-5 in 2 file lines facing each other, about 10 paces apart.
- Place spot marker under 1st student in each line.
- The ball is at the foot of 1 of the line leaders.



GO!

1. The object is to make a controlled pass to a groupmate and follow it.
2. The 1st person in each line stands behind their spot marker.
3. If you have the ball, pass it to the 1st person in the opposite line, and then run to your R to the end of that line.
4. Receivers trap to settle the ball, then pass it back quickly. After passing, remember to run to your R and the end of the line you passed to.
5. Continue passing and following until stop signal.

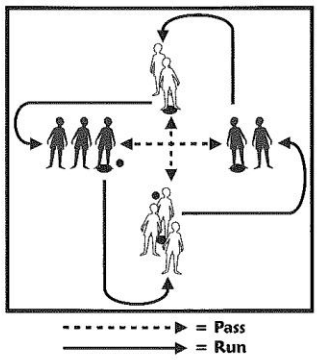
CHALLENGES

- How quickly can your group complete 1 cycle (everyone in original place)?
- Can you alternate using your R and L foot each time you pass?
- For 1 cycle, count every touch on the ball (e.g., trapping, collecting and passing touches). Can you reduce the number of touches and still make quality passes?

CUES

- Passers, pass to the spot. Keep your passes on the ground. Move quickly after you pass.
- Receivers, wait for the pass at the spot. Move to the ball. Trap and collect the ball before you pass back.

4-LINE CRISS-CROSS



GRADES 3-6

SOCCER

21

- 4/5
- Demo throwing
- students play catch
- **Activity 2: (10 minutes)** I will tell students that they were on a boat at sea and the boat crashed and their friends fell into the water. The student's job is to stand on the boat (sideline of basketball court) and throw a ring buoy (soft ball) in order to save them. The students cannot be saved unless the ball is caught. Students at sea will be in a life raft (inside a hula-hoop) and cannot step outside of their life raft. Once the student catches the ball the student must then pretend to "pull" the student into the boat. Students will have a partner they will originally throw to, but as students are rescued more can join in throwing to rescue the student. A ball may be retrieved by the rescuers (throwers) since the players in the life raft cannot leave their hula-hoop. The first round will last about 3 minutes, then students will switch spots and play another round.

Token football PEuniversity
5 Students have token. point scores for each students for each students who cross the end line of the field.
flags, balls for each student and 5 token

Triangle passing 3 dots pairs of students move from dot to dot.pass to student standing on dot.

Chicken football rock pass scissor peuniversty

Grades2/3 pyramids

Grades High 5 - 1 overhand throwing

Students have a hoop and a football. Throw to the person in the hoop. If they catch it switch places. Throw takes the hoop and places someplace where the can catch the ball.

University of Minnesota - Physical Education - Lesson Plan

Name: Amy Stiehl

Lesson Name/Number: Volleyball-Forearm Passing Grade Level: 2-5 Unit: Volleyball

<table>
<tr>
<td>Objectives:

A. Psychomotor:
• Students will demonstrate proper volleyball forearm passing

B. Cognitive:
• Students will recall to correct form and tips of forearm passing

C. Affective:
• Students will work together to succeed in the volleyball activities

I can statements:
• I can find self-space
• I can complete a forearm pass by tossing to myself
• I can forearm pass over a volleyball net
• I can perform a controlled forearm pass to a stationary person
• I can describe how to complete a forearm pass
• I can work with others during activities
• I can cooperate in small group activities
• I can help my classmates learn to forearm pass</td>
<td>Standards:

Meets standards 1,2,3,4,5</td>
</tr>
<tr>
<td>Previous Experience:

Students have previous volleyball experience, but levels of volleyball skills will be very different. Most students have had volleyball experience during physical education class, some students have additional playing experience, and some may not have any prior experience to volleyball.</td>
<td>Equipment Needs/Safety:

30 volleyballs
Volleyball nets
30 bean bags
30 boxes with nutrition labels

Jog around the outside of the cones
Keep head up when running to avoid collisions
Keep head up when jumping to avoid collisions
Use soft tagging</td>
</tr>
</table>

Appendix E.

Consent and Assent Forms

CONSENT FORM

Children's Physical Activity and Psychosocial Beliefs in Application-based Physical Education

Your child is invited to be in a research study of the effect of mobile application-based physical activity program in gym class on children's physical activity and psychosocial beliefs. We ask that you read this form and ask any questions you may have before deciding whether your child will participate in the study. **Please sign and return this form if you DO NOT want your child to participate in the study**. This study is being conducted by: June Lee, School of Kinesiology, University of Minnesota-Twin Cities.

Background Information

The increased prevalence of childhood obesity in the U.S. in the past decade is partly due to low physical activity. Physical activity programs that rely on mobile applications (apps) have become an innovative method to help individuals change to a physically active lifestyle. Exercise-related apps help individuals stay motivated as they implement physical activity plans, and keep track of their activities. However, most studies to date examining the effectiveness of app-based physical activity program are among adults. Studies examining the effectiveness of mobile apps in increasing children's physical activity levels are limited with few study of this type conducted within physical education.

The aim of this study is to compare children's physical activity levels and the psychosocial beliefs (e.g., confidence, outcome expectation, social support and enjoyment) between app-base gym class and traditionally-led (comparison group) gym classes.

Procedures:

If you agree your child to be in this study, we would ask your child to do the following things:

Your child(ren) will be asked to fill out a questionnaire and wear an accelerometer (activity monitor belt) during gym classes at school. Children will not wear the belt outside of gym classes or school and will be asked to wear the belt for three gym classes. Children The monitor is lightweight and resembles a beeper. Your child will be instructed to wear the monitor on the right hip, attached by a belt, only during three gym classes. Questionnaire on children's psychosocial beliefs will distributed to children to

fill out in the third gym class (once). An incentive gift card ($10) will be given to each child for completing the survey and wearing the belt for three gym sessions.

Risks and Benefits of being in the Study

Risks Associated with Participation:
Although adverse outcomes due to children's participation in this study is incredibly low, participation in any form of physical activity during physical education has physical risks which include dizziness, muscle soreness, fatigue, shortness of breath, muscular strains/sprains, and cramping. Psychological risks, while highly unlikely, could include frustration resulting from the assessment of psychosocial beliefs.

Benefits Associated with Participation:
There may be no direct benefit to your child(ren). The indirect benefit to participants is a possible increase in physical activity levels. Further, as a result of participation in the study, your child(ren) might become more aware of how fun physical activity can be and develop a desire to try other physical activity.

Compensation:

To compensate your child for his or her time as a participant in the study, all children who complete the study will receive an incentives (e.g., snack, sticker, or etc.).

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. Study data will be encrypted according to current University policy for protection of confidentiality.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your child(ren)'s participation or non-participation will not affect the child(ren)'s grade in physical education or their relationship with the school. Additionally, your child(ren)'s decision whether or not to participate will not affect his or her current or future relations with the University of Minnesota. If your child(ren) decide to participate, he or she is free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study is, June Lee and child(ren) may ask any questions he or she have now. If your child(ren) have questions later, **he or she is encouraged** to contact June Lee at 612-301-9199, or leex6924@umn.edu.
If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

Your child(ren) will be given a copy of this information to keep for his or her records.

Statement of Consent:

I have read the above information. However, **I DO NOT agree** to let my child(ren) participate in the study. **** Please sign if you do NOT want your child to participate in the study.**

Signature of parent or guardian:_____

Date: _____

Signature of Investigator:_____

Date: _____

Participant Assent Form

Physical Activity and Beliefs in Physical Education

Hello, my name is June and I am a student at the University of Minnesota.

I am doing a study and would like to know how you feel during gym classes and how much physical activity you get during them. If you would like to be in this study, you will be asked to answer a survey once and wear the activity monitor belt for three gym classes. The activity monitor belt will not affect your movement or hurt in anyway.

When filling out the survey, there are no right or wrong answers. So please answer the questions truthfully. Please ask any questions you have. You can always say that you do not want to take the surveys at any time.

Once you finish answering the survey, I will not share your thoughts with anyone. No one will see your answers, not your teachers, classmates, or parents.

Your decision whether to take part in this study or not will not influence your grade in physical education or your relationship with the school.

Writing your name here means that you have read this paper (or have read it to you) and that you are willing to fill out the survey and wear the activity monitor. If you do not want to participate, do not write you name on the paper. Participating is up to you.

Your Name _____

Date _____

Signature of person explaining the study _____