The Impact of Technology-Enhanced Classroom Physical Activity Interventions on Executive Function, Motivation, and Physical Fitness.

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Kinesiology)
in the University of Michigan
2016

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Acknowledgements

I gratefully acknowledge the assistance, support and encouragement of my dissertation committee members Weiyun Chen, Natalie Colabianchi, Kai Cortina, and Thomas Templin. I would especially like to thank Weiyun Chen for her continued assurances that this was something within our grasp, and Kai Cortina, without whom I would have struggled even more with my statistical analysis. Special thanks also are extended to the four elementary teachers, whose dedication to their students made it possible to conduct this research. I would also like to thank the two camp program chairs Kerry Winkelseth and Brittany Burgess, who encouraged me to work with their students on developing and pilot testing the original program. Without your support this program may not have been feasible. I would like to extend a special note of thanks to Teri Clancy, who kept at me to finish my PhD, and my sister Libbie who helped with editing. I would like to thank my friends: I wish I could name you all! Finally, my family—Mike, Alex, and Nicole—for their love, encouragement, understanding and support during my long hours away from home.

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Abstract

The main purpose of this study was to investigate the impact of technology-enhanced classroom-based physical activity interventions on executive function, physical activity, aerobic fitness and motivation. Two intervention groups (Physical Activities Engaging the Brain (PAEB) + Fitbit Challenge (C) and Fitbit Only (Fitbit-O)) and one comparison group were examined from two schools (N=116). The first study examined whether students exposed to daily coordinated bilateral activities showed an increase in executive function, measured by the d2-Test. Children in the PAEB-C group showed significant improvements on the d2-Test compared to the other two groups ($p < .01$).

The second study examined if children in the Fitbit groups (i.e., PAEB-C and Fitbit-O) improved their fitness over the comparison group, whether the PAEB-C participated in more physical activity than the Fitbit-O students, and if an individual's fitness was correlated to their d2-Test scores. The study revealed significant improvements in fitness between the Fitbit groups and the comparison ($p < .001$), but not between the PAEB-C and the Fitbit-O. Children in the PAEB-C took significantly more steps, 2206 per day, and were significantly less sedentary than the Fitbit-O. Student's fitness scores were directly correlated to the d2-test ($p < .01$).

The final study investigated whether the addition of Fitbits increased a child's motivation and attitudes compared to the comparison group. Both Fitbit groups scored significantly higher for autonomous motivation and attitude (AMA) ($p < .05$) relative to the comparison group. The PAEB-C also scored higher for Self-Perception (SP). Finally, along with the pre-test for fitness, AMA and SP were predictive of a student's post-fitness test ($p < .001$).

This study highlights the benefits of adding a Fitbit physical activity intervention into classrooms to improve executive function, motivation and fitness. It is the first to use a child's motivations and attitudes to predict a student's future fitness. It reveals that an easy-to-use, minimal interruption intervention is a feasible addition to any school, and it can improve fitness, physical activity, attitudes, motivation and executive function in the classroom. It may also have possible critical policy implications for future classroom-based physical activity interventions.

Key words: Fitbit, Executive Functioning, Self-determined Motivation Physical Activity and Fitness

Chapter 1

Introduction

Due to reported concerns about children's inability to pay attention in school settings, teachers and schools are seeking out educational models that can positively impact a student's ability to concentrate and focus (Budde, Voelcker-Rehage, Pietrassyk-Kendziorra, Ribeiro & Tidow, 2008). This focus on attention coincides with global declines in children's physical activity levels. Increased sedentary behaviors are further exacerbated as children mature into adolescence, since physical activity levels continue to decrease at a rate of about 7% per year (Dumith, Gigante, Dominigues, & Kohl, 2011; Lowry, Lee, Fulton, & Kann, 2009; Sallis, Prochaska, & Taylor, 2000). As a result of this decline, which persists into adulthood, physical inactivity is thought to be one of the biggest public health concerns in America (Blair, 2009). However, many believe that the problem of inactivity goes beyond physical health. A growing body of research has focused on the relationships between physical activity, fitness, and executive functions (Mura, Vellante, Nardi, Machado, & Carta, 2015; Rasberry, Lee, Robin, Laris, Russell, Coyle, & Nihiser, 2011). However, despite the findings, which indicate that physical activity is positively associated with academic achievement, adolescents and school aged children continue to fail to meet the recommended daily levels of physical activity. (United States Department of Health and Human Services [DHHS], 2012).

My research explores how coordinated bilateral activities can be used to stimulate improvements in attention and concentration. At the same time it examines how a Fitbit technology-enhanced intervention can be used to facilitate improvements in physical activity levels, fitness, and motivation as well as the interaction between executive function and fitness and the predictive nature of motivation on a child's fitness.

Purpose of the Study

The purpose of this dissertation is to examine the relationships between technology-enhanced physical activity, motivation, fitness, and executive function in fifth grade elementary students. The dissertation is comprised of three distinct studies. Study 1 investigated the impact of coordinated bilateral activities on executive function. Study 2 investigated the effect of using a fitness-enhancing tool (Fitbit) alongside a Fitbit Challenge on a child's cardiovascular fitness and physical activity levels. It also explored if a relationship existed between a child's fitness and executive function. Study 3 explored the effect of introducing the Fitbit device as well as motivationally based Fitbit Challenges. Outcome variables included a child's motivation to be physically active, the child's physical activity levels, and post-fitness tests results. Furthermore, this study investigated whether children's pre-test autonomous forms of motivation, and pre-fitness tests could be used to predict a child's post-fitness test.

Hypotheses

Study 1:

Hypothesis 1: Students in the Physical Activities Engaging the Brain (PAEB) + Fitbit Challenge (C) group will demonstrate a greater increase from pre- to post-test in their attention (measured by the d2 Test of Attention) than the Fitbit Only (Fitbit-O) and the Comparison groups.

Study 2:

Hypothesis 2a: Average physical activity levels will be higher for students in the PAEB-C group than the Fitbit-O group.

Hypothesis 2b: From pre- to post-test, Fitbit-O and PAEB-C groups will show greater increases in cardiovascular fitness compared to the comparison school.

Hypothesis 2c: At baseline, children in the Healthy Fitness Zone (HFZ) and the High Fit Zone (HF) will do better on the d2 Test than those who are below the recommended Health-Related Fitness Zones (HRFZ).

Study 3:

Hypothesis 3a. Students in the PAEB-C and Fitbit-O groups will demonstrate higher levels of autonomous forms of motivation and attitude, and lower scores in more controlling forms of motivation than the comparison group in both the pre- and post-tests.

Hypothesis 3b. Students with higher pre-test and post-test mean scores for autonomous motivation and attitude (AMA) and self-perception (SP) will be more active and less sedentary than children with lower scores for AMA and SP.

Hypothesis 3c. Students with higher pre-test and post-test mean scores in AMA and SP will have higher aerobic fitness than children with lower scores for AMA and SP.

Hypothesis 3d. Autonomous forms of motivation and attitude can be used to predict a student's changes in cardiovascular fitness from pre- to post-test.

Significance of the study

The significance of these studies lies in the quantitative findings which are designed to establish a relationship between:

1. Coordinated bilateral activities and executive function.
2. A child's fitness levels and the PAEB-C and Fitbit-O interventions.
3. A children's amount, intensity, and duration of physical activity and the PAEB-C and Fitbit-O interventions.

4. A child's fitness levels and executive function
5. A child's motivation and attitudes towards physical activity and the child's physical activity levels and fitness.

Assumptions

It was assumed in this study that:

1. Participants understood the questionnaire and test items and responded to them truthfully to the best of their ability.
2. Participants represented a normal population of fifth grade students in a Title I school in Southeast Michigan.
3. Participants understood and followed the PAEB and Fitness Challenge activities developed for the research.
4. Participants were not influenced by the researcher.
5. Participants' responses and assessments were not influenced by their peers.

Limitations of the study

This study was quasi-experimental in design. The comparison group, though similar geographically and in social economic status (SES), was not randomly assigned. Schools were chosen based on convenience and teachers' willingness to collaborate with the researchers. The implementation of the intervention was also subject to the teachers' own educational choices.

For the current study this means:

1. Selection of the participants may limit the generalizability of the results of this study.
2. Variations between the PAEB-C and Fitbit-O school and the comparison school in race and social economic status exists among the research participants.

3. Participant’s level of fitness and or level of motor skill may have influenced student responses.
4. The measurement tools used may have caused additional random variability, through measurement error in the Fitbit activity indicators or reading difficulty in the assessment of attention via a reading-based measure like the d2 test.

Chapter 2

Literature Review

This chapter is organized into three sections: an overview of the problem, definitions of the key terms used in the research, and current research that supports dissertation studies 1, 2, and 3. Section three is further broken down into categories based upon the three studies in the dissertation. The literature for study 1 examines: (a) the impact of physical activity on executive function, and more specifically, (b) how coordinated bilateral physical activities affect executive function. Literature reviews for study 2, examine the relationship between physical fitness and executive function. The final category for study 3 examines the self-determined motivation theory in relationship to: (a) physical activity and fitness, and (b) executive function.

Overview of the Problem

According to the Centers for Disease Control ([CDC], 2013a), 15% of youth aged 12-19 did not even exercise one day a week for 60 minutes. Meanwhile, sedentary behaviors, like playing videos, rose from 21% to 41% in 2011 and 2013 respectively (CDC, 2013b). Approximately 3.2 million deaths are attributed to physical inactivity, making it the fourth leading risk factor for global mortality (WHO, 2015b). The low levels of participation in physical activity are even more striking when contrasted to the physiological benefits of regular physical activity (Janssen, & LeBlank, 2010; Melnyk, Jacobson, Kelly, Belyea, Shaibie, Small, O'Haver, & Marsiqlia, 2015) and psychological (Wankel, 1993) and academic achievement benefits (Rasberry et al., 2011).

Increasing evidence supports a positive relationship between physical activity and academic outcomes (Rasberry et al., 2011). However, the evidence is not exhaustive. It is only recently that researchers have begun to look more closely at the impact of physical activity on executive and cognitive functions (the key mental activities involved in learning) (Mura, Vellante, Nardi, Machado, & Carta, 2015; Tomporowski, Lambourne, & Okumura, 2011). For example, physical activity has been used to improve executive function (Budde, Voelcker--Rehage, Pietrassyk-Kendziorra, Ribeiro, & Tidow, 2008) and problem solving (Pesce, Crova, Cereatti, Casella, & Bellucci, 2009). It has also has been shown that physical activity does not impede learning when it replaces core academic subjects (McNaughter & Gabbard, 1993; Raviv & Low, 1990).

Further, it is widely believed that physical activity improves motivation and has a positive impact on attitude and health-related outcomes (Sallis & McKenzie, 1991). But less is known about the reverse relationship—that is, how motivation to be physically active can be improved to increase physical activity levels and fitness. Only a few studies have examined this phenomenon (Graham, Sirard, & Neumark-Sztainer, 2010; Ntoumanis, 2010; Riiser, Ommundsen, Smastuen, Londal, Misvaer, & Helseth, 2014b). For example, Ntoumanis (2010) found that there was a direct correlation between positive perceived competence and intrinsic motivation and increased physical activity levels. However, this study, like the others, did not look at fitness but instead used activity measures to represent fitness. Therefore there is a need to focus on studies that examine a child’s motivation and attitudes alongside the child’s physical activity levels and fitness.

Definition of Terms

Physical Activity and Fitness

Any movement produced by the skeletal muscles is considered physical activity. This movement can include physical labor, sports activities or movements found in everyday life. It can be static, semi-static, or dynamic (McManama, 2014). Physical activities are rated based upon several components, like the type, duration, frequency, intensity, or volume. This study focuses on the type of activity (PAEB), the duration (activity minutes) and the intensity (sedentary, light, fairly and very active). Fitbit Heart Rate Monitors (Fitbits) were used to gather heart rate data (intensity) and to collect and measure physical activity output (PAO). The PAO was measured by volume = total number of steps taken, by intensity = low, moderate, and vigorous physical activity in Metabolic Equivalents (METs), and by duration = activity minutes.

Cardiovascular fitness, though sometimes improperly used synonymously with physical activity, is the ability of the body to supply oxygen-rich blood to the working muscle tissues: it uses aerobic and cardiorespiratory endurance to insure that the muscles can use oxygen to produce energy for movement (McGraw-Hill Concise Dictionary of Modern Medicine, 2002). This research will utilize two aerobic distance fitness assessments. These measures include the Progressive Aerobic Cardiovascular Endurance Run (PACER) test and the 1 mile walk/run. The data obtained with these measures will be used to categorize students into health-related fitness zones (HRFZ), including High Fitness (HF), Healthy Fitness Zone (HFZ), and low fitness (LF) (Cooper Institute, 2015).

Academic physical activity is a method of allocating time for physical activity that incorporates academic concepts like addition or subtraction, into the physical education lessons.

It is often used to try to improve concentration, cognition, or to improve specific academic core subjects, like math and reading.

Executive Function

It is impossible to completely separate out cognitive and executive functions. Cognitive functions besides episodic or working memory and language includes attention, processing speed, response, and inhibition, which are key elements of executive functioning (Davidson, et al., 2006). Executive functions help an individual remember, prioritize, pay attention, and get started on tasks (Elliot, 2003) and is most commonly associated with activity in the prefrontal cortex (NIH, 2015). Bull and Scerif (2001) maintain that executive functioning is key for scholastic development and that it can be used to predict children's academic success, particularly as children move beyond elementary school (Greenwood, Delquadri, & Hall, 1989).

For the purposes of this dissertation, attention will be the focus indicator of executive function. This will be measured by the d2 Test of Attention (d2 Test) (Birkenkamp & Zillmer, 1998). Attention can be broken down into three categories: selection, processing, and sustainability. Selective attention is the ability to attend to stimuli while disregarding irrelevant information and distractions, measured with the d2 Test as Concentration Performance (CP). Processing relates to speed, measured by total number of items processed (TN), and accuracy — total number of items minus the total number of errors (TNE). Though young adults are often better at processing information quickly (McDowd & Shaw 2000), they may be more susceptible to distractions (Bopp & Verhaeghen, 2005). Sustained attention allows an individual to maintain concentration over an extended period of time, which is measured as Fluctuation Rate (FR) (Birkenkamp & Zillmer, 1998). This type of vigilance may be more difficult in young children (Riddle, 2007) and can cause two types of errors. Errors of Omission (E1) are when the they miss a correct answer and Errors of Commission (E2) when they choose a distractor. Both capture this aspect in the d2 Test and can be combined with CP to form Error Percent (E%).

Coordinated Bilateral Activities

The Physical Activities Engaging the Brain (PAEB) modules are designed to encourage coordinated bilateral movements. They focus on low intensity gross and fine motor skills, which use both sides of the body, or more than one body part at a time. These are sometimes known as bilateral skills, and when the activity is done together they are called coordinated (Hay, 1985). These actions rely on hemispherical actions, since both sides of the body are engaged in the cross lateral motions needed to carry off the activity. Some of the activities also cross the midline or sagittal plane of the body. Since the activities themselves are not meant to increase fitness, it is hoped that the bilateral activities can foster improved motor skills, perceived competence, and executive functioning. This is derived from the theory that children, as they continue to grow, use these activities for self-care (putting on a sock, or shoes), when participating in sports (e.g., throwing a ball) and physical activities (e.g., skip), but they also use them in activities like reading or math (McManama, 2014). In reading, children must be able to move their eyes from left to right across a path, without any interruptions. A child who has difficulty with bilateral activities or coordination may struggle with these types of activities (Franke, 2005).

Motivation

A theory commonly used to study learning motivation is the Self-Determination Theory (SDT), which is a meta-theory of motivation in general (Deci & Ryan, 1985). It defines intrinsic and extrinsic motivation sources and describes how they affect cognitive and social development in individuals. It is designed to help facilitate the understanding of an individual's initiative or volition. SDT describes the conditions which support an individual's experience of autonomy, competence, and relatedness (Deci, Ryan & Williams, 1996; Grolnick, & Ryan, 1989). This dissertation study used the Children's Physical Activity and Attitude Behavior (PAAB) inventory to assess student's intrinsic motivation, extrinsic motivation, amotivation, perceived competence and control, and attitudes towards physical activity (Chen & Hypnar, 2015). This self-reported inventory looks at children's motivation and attitudes towards physical activity using a five-point Likert scale. This study will measure these conditions in order to determine if there are certain distinguishing factors that explain why students participate in physical activities and if those same measures are directly related to improvements in fitness (Reeve, Deci, & Ryan, 2004).

SDT classifies motivation into three types: intrinsic, extrinsic, and amotivation (Table 2.1) (Ryan & Deci, 1991; 2000). Intrinsic motivation is a reflection of an individual's natural predisposition to learn and adjust. Extrinsic motivation is further broken down into external regulation, introjected regulation, identified regulation, and integrated regulation, and is considered an outside controlling form of motivation. Amotivation is the absence of enjoyment and can be due to a person not valuing the activity. External regulation means that the individual acts for the purpose of receiving some outside or external reward, or as a way to avoid a punishment or negative outcome. Introjected regulation manifests as feelings of guilt or a sense of duty, which can be based upon peer or parental pressures. Identified regulation is a desire to achieve an outcome that is based upon an individual's own values or beliefs, but which may not be something that the person wants to do. Though also external in nature, integrated regulation relates to the engaging in activities for oneself, the closest an internalized regulation can come to intrinsic motivation, which is the only the case if an activity fulfills one of the three fundamental needs of the individuals (need for competence, social affiliation, and autonomy) (Bryan & Solomon, 2007).

Table 2.1 Autonomous Motivation, Perceived Relatedness and Controlling Study Framework

Motivation Type	Subcategory	Definition
Autonomous Motivation		
	Intrinsic	A natural desire to want to do something which is a reflection of an individual's natural predisposition to learn and adjust
	Attitude	A way of thinking or feeling about a person, activity or event which is then reflected in a person's behavior.
	Identified	A desire to achieve an outcome that is based upon an individual's own values or beliefs, but which may not be something that the person wants to do.
	Integrated	Though external in nature it relates to the engaging in activities for oneself.
Perceived Relatedness		
	Perceived Control	Belief that an individual can bring about desired outcomes or changes.
	Perceived Competence	Measures how capable an individual feels about what they are able to do
	Perceived Autonomy	Perception of freedom of choice or state of acting separately from others.
Controlling		
	External Regulation	For the purpose of receiving some outside or external reward, or as a way to avoid a punishment or negative outcome.
	Amotivation	The absence of enjoyment with regards to the activity or event.
	Introjected	Feelings of guilt or a sense of duty which can be based upon outside pressures.

SDT also focuses on how social and cultural dynamics can improve or detract from a person's incentives. In this study this is measured by a person's perceived control, competence and autonomy as well as their attitudes toward an activity (Ryan & Deci, 2000). Perceived control is defined as a belief that an individual can bring about desired outcomes or changes (Wallston, Strudler-Wallson, Smith & Dobbins, 1987). Perceived competence measures how capable an individual feels about what they are able to do (Fulmer, 2014). Children who believe that they can do something are more likely to participate in the activity and to feel a greater sense of autonomy as a result (Fulmer, 2014). When individuals feels competent and autonomous they become driven intrinsically to persist in that activity (perceived competence). When they feel a certain freedom to make their own decisions about their activities (perceived control), they make the experiences their own, further enhancing the activity (Ho, Liao, Huang, & Chen, 2015).

Fitbit Challenge

Using the above study framework for motivation a Fitbit Challenge was created for this study. This challenge was designed to get students to begin to think about their own physical activity. Children were given a very popular new technology, the Fitbit Charge HR (Fitbit) monitor (Fitbit), in hopes that its reputation would get kids excited about physical activity, and thus target intrinsic motivation and attitude. Because the Fitbit collects daily activity data in steps, miles, and in activity minutes, which can be monitored by the individual wearing the device, this will allow students to feel has if they have higher perceived control over the choice of whether or not to participate in physical activity. Additionally, a Fitbit Challenge worksheet, to be monitored by the children themselves, will allow students to engage in the activity based upon their own integrated and identified desires to accomplish the challenges. This also will target their autonomy, by giving them a choice: if they want to take part in daily or weekly challenges they can, but they are not being forced to follow any specific treatment. Finally, weekly updates giving daily and weekly averages in distance, steps and activity minutes can allow children to see their accomplishments with relationship to the class and to the goals they set for themselves. The challenges begin by asking the children to keep track of their own physical activity, and thus to take part in the intervention by being proactive for themselves.

Impact of Physical Activity on Executive Function

A large number of studies show consistently positive associations between academic performance and physical activity (Castelli, Hillman, Buck, & Erwin, 2007; Sibley, & Etnier, 2003; Strong, Malina, Blimkie, et al., 2005; Taras, 2005; Tomporowski, Davis, Miller & Naglieri, 2008; Trost, 2007; Trudeau, & Shephard, 2010). However, examining the relationship of physical activity and executive functioning is a much more recent endeavor (Mura et al., 2015). Still, it is generally agreed that physical activity may have a positive impact on a student's ability to attend to and organize ideas presented in class (Conyers, & Wilson, 2015). Conversely, Simpkins, Fredricks, Davis-Kean, and Eccles (2006) suggest that when testing is associated with higher ordered measurements, like memory, aptitude, perception, and reasoning the results are only sometimes conclusive. This adds merit to looking at the most basic function of attention and concentration, which can act to help develop higher ordered cognitive functions.

Individuals are more likely to have better mental focus and concentration when taking part in structured physical activity (Katz, Cushman, Reynolds, Njike, Treu, Walker, Smith, & Katz, 2010). But how teachers should structure the activity and to what extent they should integrate physical activity into the curriculum remains unclear. Since this study focused on classroom-based interventions this will be the focus of the next section. The following section will focus on outcomes specifically related to academically-targeted physical activity sessions.

In a systematic review of the literature, Rasberry et al. (2011) present a wide range of empirical findings on the connection between physical activity and a child's academic and cognitive skills. These include studies reporting positive or no negative associations between physical activity and cognitive skills, academic behaviors, and academic outcomes. Of those examined, nine studies were classroom-based and all reported significant positive effects on cognitive development (Fredricks, Kokot, & Krog, 2006; Valle, Dunn, Geisert, Sinatra, & Zenhausern, 1986) and academic achievement (Ahmed, Macdonald, Reed, Naylor, Liu-Ambrose & Mckay, 2007; Donnelly et al., 2009; Kibbe, Hackett, Hurley, McFarland, Schubert, Schultz & Harris, 2011; Uhrich & Swalm, 2007). Only a few studies investigated executive function as an outcome variable. Maeda and Randall (2003) examined second grade children (N=19) in one classroom. Within this class, students were assigned to low achieving and grade level groups and were asked to walk or run for five minutes just outside the classroom, four days a week just prior to doing one minute math tests. Overall, all students exhibited increases in math fluency scores and behavioral reports: teachers indicated that students were more likely to be on task and to complete their work faster. However behavioral results were reported only anecdotally by the teacher. Additionally, though assessment was organized by the classroom teacher, the exercise happened outside of the classroom, in a setting more similar to recess.

Other studies focused on executive function by using qualitative data. For example, Norlander, Moas, and Archer (2005) examined the executive functions from teacher-rated concentration levels and student self-reported stress levels on primary and secondary students, averaging 11.35 years of age (N=84). Sound monitors were employed to see if the relaxation reduced threshold noise levels made by the children, which was thought to reflect a better environment for working memory and concentration. The researchers found that a 4-week program of stretching and progressive breathing did not reduce stress but that noise levels were lower and concentration was higher following the sessions (Norlander et al., 2005). In the Class Moves Project (Lowden, Powney, Davidson, & James, 2001), students focused on using quiet movement (balancing, stretching, etc.) and sometimes more vigorous movement (walking, dancing, etc.) in a relaxation exercise program. Teachers' qualitative reports from diaries and logs indicated that both teachers and students found the activities enjoyable, and that teachers felt it helped students to refocus and concentrate better in the classroom. This supports the use of small motor skill movements, which will be employed during the PAEB activities. A study with 15 minutes of added activity (Hill et al., 2010) with children aged 8-11 years (N=1025), showed improvements in listening span on days the children exercised, but not on days when the children did not take part in the activities. These results are memory related, so they cannot be said to directly improve executive function, but the assessment included listening with recall, so attention though not measured, was involved.

Many of the most successful interventions using physical activity in classrooms to improve academics and cognitive functioning include an academic component. One such study ("Take 10!", Kibbe et al., 2011) focused on using 10 minutes of classroom time for physical activity with academic concepts. Take 10! was successful at improving overall scores in math, spelling and reading. Additionally, in a follow up conference, teachers considered Take 10! a reasonable activity for regular use in the classroom since it took very little time out of academic learning time (Kibbe et al., 2011). Like the Take 10! study, Vazou and Smiley-Oyen (2014) found that 10 minutes of math-based physical activity improved math scores in fifth grade children (N=35). In addition, the researchers also measured children's enjoyment of the activity and success at suppressing inappropriate responses, using the Flanker Test. The results from the

Flanker test indicated that children's attention and executive function were improved after doing the physical activities. The children also indicated that they enjoyed the activities. Both results illustrate that added physical activity does not reduce attention in the classroom and it may improve a child's outlook towards physical activity. Sun (2013) did find that during the transition from elementary to middle school, young adolescents with higher levels of activity outside of school struggled academically. However, she also found that those with higher levels of activity did much better in school as they got a little older. The classroom-based activities in this dissertation study will not compete with homework or other outside activities during early adolescence. This is important, since it provides children with small breaks in school during which the children can be physically active, and these short physical activity sessions within the classroom can be effective in promoting executive function.

To add even more physical activity into the school day, Physical Activities Across the Curriculum (PAAC) (Donnelly et al., 2011) focused on insuring that the intervention added enough physical activity for students to meet their daily recommended levels. In this large scale study, PAAC used longer academic physical activity (90 minutes a week) in addition to physical education. In PAAC, researchers used the Wechsler Individual Achievement Test (WIAT-II-A: The Psychological Corporation, 2001), a measurement of reading writing, and math scores, which were combined into a measure of cognitive function. The results showed significant improvements in cognitive functioning and in physical activity levels. However, the training time for teachers included six hours of in-service for the teachers each year the program was being used. The added time for training and for additional lesson planning may make it difficult for some districts to keep the program going. Thus it merits investigating whether physical activity without academic lessons and a shorter duration can have similar positive effects.

Similarly, Mahar, Murphy, Rowe, Golden, Shields, & Raedeke (2006), introduced energizers (10 minute physical activity lessons) to 135 students (N= 243) and measured Time-on-Task (T-O-T) alongside academic improvements. Pre-service training time for teachers was reduced to 45 minutes, and teachers were given booklets that included examples of how to incorporate the lessons into their classes. Teachers were encouraged to try to implement academically integrated physical activities lasting 10 minutes each day. In addition to academic improvements, TOT was measured by trained observers, who confirmed significantly higher TOT levels in the energizer groups (Mahar et al., 2006). Additionally, the energizer groups took a significantly higher number of steps than the control group by the end of each day (Mahar et al., 2006). These types of interventions can be incorporated more easily into the classroom routine with less additional work by the teachers and may prove to be more sustainable. Still, they continue to require more preparation time for the teachers.

The above research brings to light new questions about exactly what kind of physical activities might be most beneficial in improving academic success (Rasberry et al., 2011) or the ideal durations of the breaks (Schmidt, Egger, & Conzelmann, 2015). Though the findings are mostly positive, the results of the review highlight a few limitations. For example, many of the studies used self-reported information for academics (like grades), or physical activity. Many required either outside specialists or additional teacher training to run the programs. In response to this, Kibbe et al. (2011) discuss the importance of finding "sustained users" for their program Take 10! Though highly successful, this program requires work that must be done on a regular basis to insure that academic content is directly linked to the 10 minutes of physical activity. To do it well, Take 10! programs take a lot of planning time. If it can be demonstrated that breaks without academic concepts can accomplish similar results it can save time and additional costs.

Finally, Lowden et al. (2001) pointed out that adding physical activities throughout the day also increased a child's learning motivation. This needs to be explored further with relationship to executive function, physical activity and fitness. It seems reasonable that many of these studies may also benefit from incorporating psychosocial measures since academic success and executive function are in part related to this factor (Bandura, Barbaranelli, Caprara,, & Pastorelli, 1996), an example of which is highlighted in Bandura Barbaranelli, Caprara, & Pastorelli's (2001) study. Children's perceptions of academic efficacy and self-regulatory efficacy directly impacted their own academic outcomes and aspirations, resulting in children who are more likely to be highly educated. This dovetails with the idea that the physical activity interventions motivate the child to be more active.

Coordinated Bilateral Activities and Executive Functioning

The ability to coordinate both hemispheres of the brain helps facilitate other skills like reading, writing, attention, focus, and memory (Jensen, 2005). Conversely, children who have difficulty crossing the body's midline often have troubles with cognitive and executive functions. As a result of this they often do not do as well academically as their peers (Hannaford, 1995). To further understand these connections, Jensen (2001, 2005) reviews the relationship between skills that require coordination, bilateral or cross-lateral motion, and executive functions in a variety of populations. Both hands often need to work together to help establish maturation of movement. Since this maturation is directly related to the executive functions it suggests that a relationship also may exist for attention and concentration. However, this relationship has not been fully examined (Stevens-Smith, 2004).

According to Dennison and Dennison (2010), children often do not learn because both sides of the brain are not integrated or working together. This hindrance to learning can be caused by stress or a myriad of other factors. When a child is unable to utilize the left and right side of the brain in an integrated manner (i.e., is unable to “cross the midline”) then learning can be hindered (Dennison & Dennison, 1994). Symmetric and asymmetric body coordination may therefore be an important aspect of physical activity to help facilitate learning. The brain uses the same connections to process reading, writing, and math (Hannaford, 1995). Kamijo and Takeda (2010) examined spatial priming tasks, which used both sides of the brain. The tasks required participants to use spatial cues along with letters to orient on a white dot. Students (N=20) who reported higher physical activity levels were much more successful at this activity. The more physically active group was also more efficient at neural networking than their control counterparts.

Jensen (2001) stated that, "If learning is not in your body, you haven't learned it.” He believes that those who think the brain trains the body have it backwards, and that it is “the body that trains the brain.” This concept of “learning by doing” or experiential learning allows children to take in information and utilize it in more efficient ways and may be integral to improvements in cognitive and executive functioning (Dale, 1969). As students dribble a ball with both hands they are using both sides of the body and thus both sides of the brain are engaged. But this type of cross lateralization does not have to involve a ball. Instead controlled movements could be ideal for smaller spaces, like those in the classroom.

One way to further understand this is to examine the relationship of coordinated bilateral movements with specific cognitive function. Pesce, Crova, Cereatti, Casella, and Bellucci (2009), focusing on the bilateral movements in sports were able to demonstrate that exercise may facilitate the consolidation of recent information for long-term storage by reducing the interference from preceding items, or by reducing the need to rehearse. They further hypothesized that both primacy- (those items seen first) and recency (those items seen last) items increased with team games, in part as a result of an increase in social interactions but also due to the physiological arousal associated with these types of movements (Pesce et al., 2009). Similarly, Budde et al. (2008) found improvements in the areas of attention with the addition of 10 minutes of coordinated bilateral activities to a sport lesson, compared to the control group. This lesson required mostly gross motor activities, and therefore is not generalizable for classroom-based lessons, but the concept is the same. Since attention is directly linked to executive function, activities that purposefully cross the midline may prove to be a way to reduce time away from class, while still promoting physical activity across the entire day. The acute exercise-cognition links also extend to children with Attention Deficit/Hyperactivity Disorder (ADHD) or other learning disorders (Pontifex et al., 2013). In a systematic review, Van der Fels et al. (2015) reemphasizes that interventions that use fine motor skills, skills of a bilateral nature, and skills with an emphasis in timing or rhythm are associated with improvements in executive function.

Physical Fitness and Executive Functioning

The detrimental effect that inactivity or lack of fitness has on cognitive and executive function has recently gained scientific attention (Khan, 2014). Newer research indicates that exercise can foster a higher level of executive functioning. But whether it is fitness alone or whether it is moderated by factors such as health status is not clear (Tomporowski, Phillip, Lambourne, & Okumura, 2011).

Though this study will focus on fitness measures, since a lot of studies use MVPA or activity as synonymous with fitness, this review will use both. In her review Chaddock (2012) found that most studies reported positive associations between brain structure and function. She also found that these associations were stronger for children who were active for an average of 60 minutes a day. Chaddock, Erickson, Prakash, Voss, VanPatter, Pontifex, Hillman, and Kramer (2012) studied functional magnetic resonance imaging (fMRI) of children who were active compared to students who were less active. Students in the high fitness group had more effective recruitment of frontal and parietal regions of the brain in subsequent testing. This was found regardless of the congruency of the testing, while lower fit children showed a decline in accuracy when the trials were not the same. All showed declines with fatigue, but the more fit children were more consistent across testing and were better able to adapt and activate neural processes while meeting goals. Van der Niet, Smith, Scherder, Oosterlaan, Hartman, and Visscher (2015) gathered daily physical activity and executive functioning from eight children aged 8-12. Sedentary behaviors were negatively associated with inhibition, measured through reaction time (Stroop Test), while higher levels of physical activity and increased fitness were directly related to improvements in visual attention and task switching both aspects of executive function (Trailmaking Test) and planning or problem solving (Tower of London). Other areas of cognitive functioning like information processing, memory, and problem solving have also been examined in relationship to aerobic fitness. Researchers found that 6^{th} graders who demonstrated aerobic fitness measured by the PACER test had the fastest cognitive responses, (the speed with which subjects processed information), memory span, and problem solving (Etnier, Johnson, Dagenbach, Pollar, Rejeski, & Berry, 1999; Jensen, 2001).

But what really happens when children see a reduction in physical activity is not fully understood. Chaddock, Pontifex, and Hillman (2011) emphasized that more evidence is needed to support the direct and deleterious effect a reduction in physical activity can have on neuro-cognition. They point to improvements in hippocampal functioning (spatial memory) and basal ganglia control (stimulus response centers) in relation to fitness as a way to support more physical activity. Furthermore, they emphasize that understanding the importance of a decrease in physical activity is made even more important in light of the continued reductions in physical education classes across school districts. Szuhany, Bugatti, and Otto (2014) further supported this by establishing that higher fit individuals were more effective at promoting neurogenesis and the development of brain-derived neurotrophic factors (BDNF), the building blocks of the brain. Although this directly relates to cognitive aging, it may also have implications on an individual's executive function.

Conversely, negative associations have been found in sedentary and low fit children. More sedentary individuals experience decreased inhibitory control or smaller dorsal striatum than their fitter counterparts (Chaddock et al., 2011). Using a technique to suppress inappropriate responses, Hillman et al. (2009) found that more fit children had fewer errors and were more accurate when tested than their lower fit peers. Similarly, Wu et al. (2011) studied pre-adolescents and confirmed negative associations with lower levels of fitness on the Flanker test. They also found slower response time and lower accuracy percentages in children who were less fit.

Event-related brain potentials (ERPs) have also been used to study brain functioning in relation to aerobic fitness. An individual's aerobic fitness has been shown to mediate the relationship between the neurocognitive process of stimulus engagement and execution in young preadolescent children (Hillman et al., 2005, 2009; Pontifex et al., 2010). This suggests that stimulating a child to have higher executive function by improving their aerobic fitness would improve the overall engagement in the classroom environment. Buck, Hillman, and Castelli (2008) aimed at demonstrating this concept by looking at aerobic fitness and executive control measured with the Stroop test. As predicted, better aerobic fitness was associated with better performance in blocking out distractions in 7- 12 year old children (Buck, Hillman, & Castelli, 2008).

From a practical perspective, seeing improvements in executive functioning as a result of fitness only matters if this relationship extends to improved academic success. Several studies were able to document this association (Bezold et al., 2014; Booth et al., 2014; Esteban-Cornejo et al., 2014; Kwak et al., 2009; Syväoja et al., 2013; Torrijos-Nino et al., 2014). Bezold et al. (2014) examined boys' and girls' change in fitness levels over time alongside academic improvement. Girls and boys who saw a positive change in fitness were most likely to see increases in academic performance as well. Those who remained at the same fitness levels saw improvements as well, but those whose change indicated a reduction in their fitness saw academic declines as well. Two studies have reported that academic achievement was lowest with children who had poorer cardiorespiratory fitness levels (Castelli et al., 2007; Torrijos-Nino et al., 2014). Syväoja et al. (2013) showed that moderate to vigorous physical activity (MVPA) was significantly correlated to academic performance, while time spent in sedentary behaviors was negatively associated with grade point average; this finding holds even after adjusting for factors like obesity and fitness (Esteban-Cornejo et al., 2014).

Physical Activity and Motivation

The SDT (Deci & Ryan, 1985) is a comprehensive way to conceptualize human motivation with the main distinction between intrinsic and extrinsic motivation (Ntoumanis, 2001). The direct relationship between students' motivation to do physical activity and their actual physical activity, their fitness and executive function, has not been widely studied.

Intrinsic motivation is one of the strongest factors that decides if a child desires to participate in physical activity (Bryan & Solomon, 2007). Like intrinsic motivation, perceived autonomy (i.e., free choice to participate) also increases the likelihood that a child will show motivation to engage in physical activity (Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003). Owen, Smith, Lubans, Ng, and Lonsdale (2014) found that the most common motivators to be physically active were autonomous forms of motivation: intrinsic and identified regulation. Conversely, when forced to participate in physical activity, children report disliking the activity (amotivation). When preteens were forced to do exercise, they were more likely to report doing that exercise less often (Sallis, Prochaska, & Taylor, 2000). Introjected motivation is the state by which an individual chooses to engage in certain behavior because someone else desires it (Deci & Ryan, 2000). Since children do not always realize that this desire is not primarily their own, it may explain why during the transition to adolescence, when autonomy becomes a more salient need, students tend to stop doing those activities. Introjected motivation has a negative association with willingness to engage in physical activity. From a motivational perspective, it is helpful to understand which types of extrinsic motivation, apart from intrinsic motivation, are most effective at encouraging children to remain active into adolescence.

Adolescents who search for autonomy also begin to exert more control over their choices. This means that extrinsic motivating factors may not have the same impact on them as before. For example, if individuals' engagement in physical activity was merely because they wanted to earn extra credit, the resulting change, as they moved into adolescence, meant that children were no longer willing to do the activity solely for the purpose of a reward (Bryan & Solomon, 2007). If the child was bored or felt incompetent he/she ceased the activity altogether. Therefore as researchers develop interventions it becomes increasingly important to find ways of engaging the childrens' interest by utilizing what is available and already interesting to them, like new technologies.

Researchers have studied ways to make an activity more appealing and ways in to get children interested in becoming more active. One obvious method is to make the experience based on a choice of the child; thereby emphasizing autonomy (Niemiec, Ryan, Deci, & Williams, 2009). Autonomy may be an important auxiliary factor to predicting a child's future physical activities (Cox, Smith, & Williams, 2008). New developments in technology may also be helpful in engaging students to consider participating more directly in physical activity (Vorderer et al., 2006). It is the assumption of this dissertation that by providing the students with the Fitbit, a physical activity monitoring tool, they will be drawn to freely choose to reference the device in their own disposable time. By encouraging students to decide to take control of their own physical activity, the device facilitates their continued enjoyment of the activity, reduced stress, and improved psychological health

Though little research has looked at the above concept, research has been done to show that physical activity does increase a student's overall motivation. It is believed that focused physical activity helps to promote self-discipline and improve feelings about oneself (Jensen, 2001). Since many students learn through kinesthetic teaching practices, Pica (1998) maintains that having students actively engaged in focused physical activity can be successful in reaching and motivating a greater percentage of students. A student's participation in physical activity may also improve his or her attitudes towards school, in particular with respect to self-efficacy (Stelzer, 2005; Zhang, Tao, & Gu, 2010). Cox, Smith and Williams (2008) were able to show that if children liked the physical activities they did in school, including during physical education, they were much more likely to report taking part in physical activities outside of school. If this can be replicated with the objective data obtained in the Fitbit schools, this further supports the concept of enhancing student enjoyment inside school, as a way to promote student engagement of physical activities outside of school.

In addition to the call for an emphasis on objective data, duration and intensity of physical activity, Rasberry et al. (2011) also called for a way to look at individual student differences using less common measures like motivation. They suggested that these might be useful in explaining inconclusive results across studies. Using technology to motivate individuals is not a new concept. However, few fitness technology studies have gone beyond the measure of enjoyment or the measurement of the increase in physical activity. And even fewer have drawn on rich theoretical models like SDT that establish a more nuanced relation between different aspects of motivation and fitness. For example, a systematic review by Lubans, Morgan, and Tudor-Locke (2009) revealed that in studies using step-tracking devices, twelve out of fourteen studies revealed significant increases in physical activity. In ten of the studies, students were encouraged to use self-monitored activity, and eight indicated improvements in physical activity steps overall. Yet no psychology factors were reported in relationship to the changes, and the studies predominantly looked at physical activity but not fitness.

Technology has been used to increase motivation in studies wherein participants are asked to use the technology to monitor and promote physical activity. In one such study, De Cocker, De Bourdeaudhij, and Cardon (2008) showed that participants significantly increased their walking and MVPA using a pedometer, after being informed of the recommendations of 10,000 steps/day. Participants who also took part in a support group reported a significantly more positive attitude towards the use of the pedometer. Kinnunen, Mian, Oinas-Kukkonen, Riekki, Jutila, Ervasti, et al. (2015) report additional advantages of using Fitbits compared to other monitors: that is, they are easy to use and are widely popular. This is important since three other studies, which tracked additional fitness habits outside of the physical activity using a pedometer, resulted in improvements in both steps taken and in health-related behaviors (Horne, Hardman, Lowe, & Rowlands, 2009; Lubans & Morgan, 2008; Lubans et al., 2009), but did not specifically look at the psychologically motivating factors behind the resulting changes.

One study, done by Mikkola, Kumpulainen, Rahikkala, Pitkanen, Korkeamaki, & Hytonen (2010), focused on promoting physical activity through technology and did examine the psychosocial changes seen in students. In this study they developed Futurestep, a program to enhance the well-being of children 14-15 years old through the use of Polar monitors. Polar monitors are similar to the Fitbit, but the tracking device in these studies was worn around the chest in addition to a wrist band They found that the use of the Polar devices increased the students' awareness of their own physical activity. This, in turn, reflected an improvement in the students' self-reported motivation to be physically active. This gives credence to using the Fitbit monitors themselves as a way to create an intervention to improve motivation and supports the notion that feedback data can be used for more than just monitoring steps. This highlights a basic premise of this research: that it is important to motivate students to want to make a change. By offering the children a simple tool to log their activity, it is hoped that children will initiate change with minimal coaching by teachers or adults. If students see improvements in fitness, motivation, and executive function, as a result of their self-monitoring, this might allow them to recognize that a relationship exists between exercising and learning successes (Conyers, & Wilson, 2015).

Motivation, Physical Activity, Exercise, and Executive Function

Eccles and Wigfield (2000) call for future research to examine how perceived competence and valuing an activity relate to doing the activity. This is the driving factor in study 3, which based on the tenet that if children are intrinsically motivated to do something, they will do better. In their review, Wigfield and Eccles (2000) found that children's ability-related beliefs (Eccles, 1993) and intrinsic motivation (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Wigfield, Eccles, Mac Iver, Reuman, & Midgley, 1991) declined as children got older. They also found that those declines were highest during the transition from elementary to middle school (Eccles, 1993), and that the declines continued on through high school (Jacobs, Hyatt, Eccles, Osggod, & Wignfield, 1999). This is important, since it coincides with declines in physical activity and in academic achievement seen over the same period. Consequently, fifth graders, who are one year prior to a transition to middle school, were chosen for this study to try to boost their feelings of autonomy through wearing the Fitbit. We predict that by choosing to do the activity and by monitoring their own successes, students take ownership of their own physical activity and improved executive functioning.

This concept is supported by Furrer and Skinner (2005) who found tudents' academic achievement was stronger when they were more motivated and felt engaged in school. Furthermore, Roeser, Midley, and Urdan (1996) found that feelings of academic efficacy and school belonging led to improved academic performance. School-based factors, such as liking school, also contribute to improved academic achievement of students (Eccles, Wigfield, & Schiefele, 1998; Ryan & Patrick, 2001). Additionally, Fredericks and Eccles (2008) found a positive association between children who participated in sports and the students' own expectations for academic success. Adolescents who participated in organized physical activities held the school in higher regard and were more positive about school. These students also showed higher levels of social and personal efficacy, while disruptive and risky behaviors were lower. It is the aim of this dissertation that these findings will be found to be true in a measurement of the child's SDT motivation towards being physically active, using the PAAB inventory.

According to the SDT, different motivational types also contribute to different cognitive, affective, and behavioral consequences in education and sports settings (Deci & Ryan, 1991; Ryan & Deci, 2000). A review of literature on motivation research (Vallerand, & Losier, 1999) highlighted that more self-determined types of motivation —namely intrinsic motivation, integrated regulation, and identified regulation —are associated with more positive outcomes in education and sports performance. In contrast, more other-determined motivation types including introjected regulation, and external regulation as well as amotivation, are associated with negative outcomes (Deci & Ryan, 1991; Ryan & Deci, 2000; Vallerand, 1997). Study 3 will examine if an increase in a child's motivation to be physically active will contribute to behavioral changes.

Furthermore, since executive functioning can be impacted by psycho-social factors (Tomporowski et al., 2011), improving these through physical activity may be another venue by which to help children improve academically. Motivation to be physically active and or improve fitness may also be directly related to a student's scores on tests of executive function. Two studies done on adults (Dishman, Saunders, Felton, Ward, Dowda, & Pate, 2006; Winter et al, 2007) report short bouts of physical activity in addition to improving cognitive function, show positive associations geared toward improving mental health outcomes. This occurs through an increase in neurotophic factors and a change in catecholamine factors. These results suggest physiological benefits from that exercise. Melnyk et al. (2015) found that physical activity, integrated into a health curriculum, improved physical fitness. They also found improvements in scales of personal empowerment, perception and reasoning, and forms of cognitive and executive functioning.

Since physical activity seems to have such a positive effect on both psychological health and academic successes, Conyers and Wilson (2015) emphasize the importance of finding creative ways to incorporate physical activity into learning or school environments. The link between being motivated to do physical activity, fitness, and improved executive functioning is not yet established. While it sounds trivial that students who like to be physically active are more likely to be physically active, this finding supports schools' efforts to develop effective ways to add physical activity back into the school day in a way that motivates kids.

Conclusion

With a consistent decline in children's physical activity (Sallis, Prochaska, & Taylor, 2000), it is time to heed the call for further studies that can demonstrate the direct effect of fitness, physical activity levels, and motivation on executive functioning (Conyers, & Wilson, 2015). Since an argument can be made that physical activity is directly related to learning and motivation, addressing this decline may be one of the most significant intervention strategies for public health. Additionally, since the most consistent environment where all children see physical activity is in schools, it is important that school administrators and classroom educators are exposed to research that links movement and motivation to learning and executive functioning. This is the goal of the study.

Chapter 3

Impact of Coordinated Bilateral Activities on Executive Function

Abstract

This study examined the impact of short bursts of coordinated bilateral physical activities on executive function in elementary school children. Participants (N=113) in fifth grade from two elementary schools were assigned to three groups: two intervention groups and one comparison group. The two intervention groups were given Fitbit Charge Heart Rate Monitors. The first group was a Fitbit-Only (Fitbit-O) intervention. The second intervention group took part in six minutes of daily Physical Activities Engaging the Brain (PAEB), as well as a Fitbit Challenge (C). All participants were pre- and post-tested with the d2 Test of Attention (d2 test). Change scores in the d2 test scores were analyzed using a general linear model. All participating children showed significant improvements from pre- to post-test. Children in the PAEB-C group showed stronger improvements from pre- to post-test than both the comparison and the Fitbit Only groups in areas of concentration performance, fluctuation rate, and total number of items processed. These results are consistent with prior studies that used classroom-based physical activities to improve executive functions. The results suggest that daily brief coordinated bilateral activities can improve attention and concentration in fifth grade students over the course of four weeks.

Key words: Coordinated Bilateral Activities, Classroom-based, Physical Activity, Executive function

Introduction

Significance of Attention and Focus in School Settings

Schools are constantly trying to find ways to improve test scores and to minimize the discrepancy in learning outcomes. The basic premise of the Common Core (2015) is to help children succeed by enabling them to think critically and to learn by doing. In order to do this, children need to know how to gather and disseminate, analyze, and evaluate information as well as how to challenge new ideas and draw their own conclusions (Common Core, 2015). In order to be successful at achieving these goals children need to be able to think critically and creatively on their way to fully understanding a concept (Parks, 2013). Bull and Scerif (2001) suggest that executive functions may play a significant role in children's success at achieving these goals. Elliot (2003) concurs and proposes that the ability to prioritize, pay attention and complete tasks (aspects of executive functioning) may ultimately contribute to a child's academic achievement (Elliot, 2003)

The ability to concentrate and the ability to attention are two key types of executive function. They involve vast areas of the brain, from the cerebellum all the way to the prefrontal cortex (NIH, 2015). As a child focuses, pathways develop and connect with the limbic, or emotional portion of the brain. These are areas that facilitate memory and motivation (Halperin & Healy, 2011). But all children struggle, from time to time, tofocus in school. The Institute for Educational Sciences (National Center for Educational Statistics [NCES], 2015) found that two outcomes mentioned by teachers as problem areas pointed to attitude and behavior of students in classrooms. Of those surveyed, 10% of teachers said that these were some of the most serious problems facing kids (NCES, 2015).

As a child loses his or her ability to focus in class, several things may occur which in the end will make it difficult to complete the task. According to the National Institute of Mental Health ([NIMH], 2015) a child with attention issues faces a series of problems when faced with a task. First, the child may find it hard to figure out how to get started on the task. As they begin to plan, being unable to conceptualize how much time a task will take makes it harder for that child to see a finish line. Then, even if the plan is wrong, they may stick to it when it is not working (NIMH, 2015). For example, children with attention problems find it difficult to accept or incorporate feedback into their work. Even though this may not happen often, all children experience these same frustrations at times. An individual's focus comes and goes, but a teacher who can help to facilitate their development and nurture responsiveness will have given the student an excellent strategy towards being able to see projects through to fruition. As there are no cures for wandering attention, finding strategies to help facilitate better focus can be hugely successful in school.

Learning strategies can be used by the student to make learning easier, faster, more effective, and transferrable to new situations (Scott, 2012). Classroom-based learning strategies do not necessarily teach students new content, but instead find ways to get children to continue to be engaged in the classroom. This study explores the use of physical activity learning strategies. Physical activity has been a relatively successful strategy to improve executive functioning and improve academic outcomes (Dresler et al., 2013). Sibley and Etnier's (2003) review concluded that there is a significant relationship between cognitive improvements, academic achievement, intelligence, perceptual skills, verbal and mathematical skills, and physical activity interventions.

Still, Diamond (2015) argues that policy has not changed. She proposes that more rigorous research should be completed, using real-world physical activity programs, to document the causality between the specific characteristics of the intervention and the benefits to the school. One such strategy involves the introduction of short bouts of physical activity to improve executive function. These have been successful at helping kids improve focus over a short period of time (Mahar, 2011; Raberry et al., 2011; Van der Fels et al., 2015). However, the physical activities have not been fully validated for use independently without academic content. Therefore, finding a way to further develop better skills to focus attention can be a key component to a successful intervention for all children.

Physical Activity Interventions to Improve Executive Functions

Van der Fels et al. (2015), in a systematic review of physical activity interventions, suggests that fine motor skills, skills of a bilateral nature, and skills with an emphasis in timing or rhythm all have moderate to high effects on improving executive functioning. Introductions of short bouts of physical activity into the classroom is one way to get children to utilize these skills on a day to day basis. Additionally, Rasberry et al. (2011) suggests that kids do not miss the time spent outside of the core curriculum while doing physical activity, based upon their academic and cognitive functioning results, and in some cases students even do better. Until now, most of the studies in classrooms have used academic physical activity lessons to improve academic, cognitive, and executive functions (Howie & Pate, 2012). This study aims to confirm that the addition of coordinated bilateral activities into the classroom can directly impact a child's executive function.

The studies highlighted by Van der Fels et al. (2015) highlight a variety of academic improvements. Some found significant improvements in math (Ahmed et al., 2007; Davis et al., 2011; Donnelly et al., 2009; Gao et al, 2013; Hollar et al., 2010; Telford et al. 2007); others in reading and spelling (Donnelly et al., 2009; Fedewa et al., 2015; Mullender-Wijnsma et al., 2015). Still others showed improvements in a child's time on task (Kibbe et al., 2011, Howie, Beets, & Pate, 2014), particularly in children who were overweight, compared to their healthy weight counterparts (Grieco et al., 2009). Mahar (2011), in a review of the literature supported the concept that students who participated in classroom-based physical activities that incorporated academic concepts or coordinated movements, were more likely to do well with attention to task than control groups. This dissertation study is based on two premises supported by the literature. The first is that classroom-based physical activities can influence improvements in executive and cognitive functioning (Donnelly & Lambourne, 2011). The second premise is that short bursts of coordinated bilateral physical activity can be used to facilitate improved attention, processing and focus.

Donnelly and Lambourne (2011) point to increasing importance of physical activity interventions in classrooms. Take 10! (Stewart et al., 2004), one such intervention, was one of the first to study the integration of physical activity into the classroom. Besides demonstrating the feasibility of combining physical activity with academic subjects, they found that they were successfully able to increase physical activity levels by just adding 10 minutes a day. In a more recent study (Ma, Le Mare, Gurd & Brendon, 2015), even shorter "funtervals" (four minute high intensity academic breaks or – "funtervals") were found to increase selective attention and reduce errors in 9-11 year olds (Ma et al., 2015).

Donnelly et al. (2009) designed a program called Physical Activities Across the Curriculum (PAAC), a series of 10 minutes of physically active academic lessons tested in a fully randomized trial. They found that the intervention schools had higher composite reading, math, and spelling scores (Donnelly et al., 2009). However, training the teachers was a complex process, and required six hours of pre-service training in addition to time to prepare the new lessons. Mahar et al. (2006) had shorter training times (45 minutes) and gave the teachers prepared academic physical activity lessons as booklets. The researchers introduced “energizers,” which lasted 10 minutes each. When the energizers were integrated into academic learning time, time on task was rated to be more efficient (Mahar et al., 2006). Even with longer training times, Texas-I-Can (Bartholomew & Jowers, 2011), a similar ongoing longitudinal study, was able to document qualitatively a willingness of teachers to use the intervention strategies. Although an encouraging finding, it may still lead to difficulties during implementation. Some schools may not be able to find time or funding to train teachers. Additionally, schools in many areas are pressured to focus on teaching core subjects in terms of resource allocation (Checkley, 2008) with a particular emphasis on addressing the achievement gap (Ushomirsky, & William, 2015), so they may be disinclined to allow teachers to get involved in additional projects.

In a large scale trial with 1224 8-11 year olds, Hill et al. (2010) were able to show improvements in a battery of cognitive tests including paced addition, size ordering, listening span, spanning backwards, and encoding digits in a test-retest method of the same students. The 15-minute high-intensity classroom activities included: jumping, skipping, running, and hopping in place. The results were inconclusive for the first week, but the second week showed significant improvements. This was a teacher-led program run by physical education teachers in the classroom. Little emphasis was placed on highly coordinated exercises, but the physical activity component was done completely independent of academic content.

Studies that incorporated shorter activity classroom breaks have been quite successful at highlighting improvements for children in schools as well. Howie, Beets, and Pate (2014) in a study of fourth and fifth grade students, used a four-tiered approach of 10 minutes sedentary versus 5, 10 and 20 minute active classroom breaks led by the research team (two-times/week for four weeks). They found that all activity breaks showed statistically significant improvements in Time on Task (T-O-T). However the most pronounced effect occurred after the 10-minute breaks compared to the sedentary breaks. Similarly, Schmidt, Egger, & Conzelmann (2015), used coordinated physical activity breaks during physical education classes and were able to not only show immediate effects, but in addition indicated that the effects of doing the physical activity breaks were actually strongest 90 minutes later. The methods of intervention as well as the timing seem to be important in designing classroom-based physical activities. Budde et al.'s (2008) intervention, which was done during physical education class, addressed a key concern of teachers: namely, concentration deficits in children. They suggest focusing not just on physical activity but on bilateral coordination, balance, and abilities to react to stimuli. The coordinative exercises led to significant improvements in children's attention measured by d2 Test of Attention. Since this study was concerned specifically with coordination, an element of motor processing, it provides further support for the idea that neural connections between the cerebellum and frontal cortex can influence executive function, even with very short bouts of exercise (Budde et al, 2008).

Several studies highlighted the link between coordinated bilateral and motor processing skills (Diamond, 2000; Molitor, Michel, & Schneider, 2015; Pedersen, 2014). Diamond (2000), in a review of studies, concluded that "Motor development and cognitive development may be fundamentally related" (p.44). Diamond (2015) pointed out that repetitive patterned movements and bilateral movements engage both hemispheres of the brain and may facilitate cognitive development of the cerebellum and prefrontal cortex. Pedersen (2014) expands upon the importance of using coordinated, lateral, and ipsilateral skills for improved motor processing by highlighting the importance of purposeful coordinated movements. In his study, students showed marked gains in motor processing with deliberate purposeful movements (contra- and ipsilateral ball bouncing), while students in the control group actually showed a decline. Based on the hypothesis that prefrontal cortex and cerebellum activation are associated with motor processing, Chen et al. (2014) examined this concept in children with Down syndrome. The results confirmed that fine motor skills (sorting on a pegboard) were directly related to verbal memory and cognitive planning. This gives additional credence to using coordinative and rhythmic activities in a classroom where all children have varying levels of fine motor control.

Siegel and Bryson (2012) wrote, "The brain has two sides for a reason: with each side having specialized functions, we can achieve more complex goals and carry out more intricate, sophisticated tasks." Furthermore, cross-lateral movements like climbing can activate both hemispheres, and if a child coordinates these movements and then crosses them the two hemispheres can work together. It is in these cases where researchers suggest that improvements in executive functions, cognitive development, and improved learning outcomes occur (Hannaford, 2007). Based on the premise that motor processing is directly associated with executive attention, the current study focused on repetitive coordinated movements as a key element in designing the PAEB. The PAEB were designed to deliberately use both sides of the body, in unison and apart from each other, to reinforce motor skill development.

Research Purpose

This study examined the effect of short bursts of coordinated bilateral physical activities on executive function in elementary school children. The study aimed at identifying improvements in attention and concentration for children who took part in the PAEB-C intervention in conjunction with the introduction of the Fitbit. Two comparisons groups were part of the design: A group that got the Fitbit without PAEB or Challenge (Fitbit-O) and a comparison group with neither Fitbit, PAEB, nor Challenge. Based upon research done in the past (Budde et al., 2008; Galootta et al., 2015; Galotta et al., 2012; Schmidt et al., 2015; Van Dijk et al., 2014) it was expected that the PAEB-C group would do better on the d2 test from pre- to post-test than both the Fitbit-O and the Comparison group.

Research Hypothesis

This study tested one hypothesis:

Hypothesis 1: Students in the PAEB-C group will demonstrate a greater increase from pre- to post-test in their attention (measured by the d2 Test of Attention) than the Fitbit Only (Fitbit-O) and the Comparison groups.

Methods

Research Design

This study used a quasi-experimental design to assign three groups of students to either the comparison (N = 56) or the experimental (N = 60) groups. Subjects were fifth grade students from three classrooms in two Title 1 schools in Southeast Michigan. The two classes in one school were randomly assigned to two conditions: Fitbit-O (N = 29) and PAEB-C (N = 31). The intervention was implemented over the course of seven weeks. The first week was used for recruitment, the second and the last week for testing the children, while the four weeks in the middle were used for the interventions. Students in the PAEB-C and the Fitbit-O groups were given Fitbit Charge Heart Rate Monitors (Fitbits) to wear for four weeks day and night, except in cases when they were going to get wet (see Appendix A). Students were able to follow their progress individually on the Fitbit wristbands, and teachers were given reports of the classroom average steps and activity minutes each Monday during the four weeks. Students were encouraged to keep track of their own information each week and to set goals for themselves. The PAEB-C students were given a Fitbit Challenge handout with which to record their activities (see Appendix B). On this handout a new challenge was assigned each week. The first was to increase steps/day and to set a goal of steps/week. Another challenge asked students to monitor their distance traveled and to set a specific geographic goals, such as to walk across Michigan and the US. Each week a new challenge was assigned and the students wore their Fitbits from Monday morning (as they arrived at the classroom) until Friday afternoon, whereupon they put the Fitbits in the charging station before they left for the weekend. Each day the PAEB-C group took part in physical activities that were designed to coordinate both hemispheres of the body and thus activate the brain. These activities were completed in the classroom with the classroom teacher. The teacher showed a six-minute PAEB activity video after the children had been sitting for 20 minutes. She was advised to do this once a day for four weeks. She showed the videos 85% of the time. The videos for these were provided through Quick Time, and are labeled Day 1 Video through Day 20. The comparison group was not asked to make any changes to their normal school day beyond taking the additional pre- and post- d2 tests of attention, which were administered in all three groups at pre- and post-test data collection.

Recruitment

Before beginning the process of recruitment, approval was obtained from the University of Michigan Institute for Review Board Human subjects (HUM00102732). The participants were recruited from three fifth grade classes in two Title 1 schools in Southeast Michigan. All of the students were sent informational letters followed by consent for the study (see Appendix C).

The letters contained a participation agreement and an informational letter. Both letters explained what the children would be doing in the study. If a consent was not returned, students were given a second consent and were asked to return the consent as soon as possible. One hundred and sixteen students signed the consent forms, with 96.9% from the PAEB-C group, 87.5% from the Fitbit-O group, and 87.7% in the comparison group. Written assent forms were also gathered for students prior to pre- and post-testing.

Participants and Setting

Two schools in the Ann Arbor area were selected based upon their similarity to each other and their availability to take part in the research. The two schools are located in neighborhoods with a relatively low average socioeconomic status (SES) for the area. The district reports an average of 21.6% of students fall into the category of free or reduced lunch, while at the study schools 43% (Fitbit) and 37% (Comparison) of the students fall into this category (Michigan Student Demographic Data [MSDD], 2014). Both schools have slightly higher than average population of ethnically diverse students for this area. In the experimental school, 60% of the participants self-selected a race other than white, with 30% choosing African American. At the comparison school, 48% selected a race other than white, with 19% selecting African American (MSDD, 2014).

Treatments

Physical activities engaging the brain (PAEB). The PAEB are designed to emphasize coordinated exercises that use bilateral body movement. These movements are repetitive and specific and use a combination of fine and gross motor elements. Based upon the results from McClelland et al (2015), the videos were meant to be progressive in difficulty to keep children engaged in the activities throughout the duration of the intervention. Thus, during the first week of the intervention the activities were done very slowly, then during weeks 2 and 3 the activities were done at a slightly faster pace. Finally, during the last week (4), the speed was further increased. An example of the fine motor movements involves repeating eight then four then two hand gestures in unison. For example, thumb and finger in the shape of an “L” followed by the pinky making and “I”, first together then opposite each other, also in the same rhythmic format. Other movements focused on changing direction, going forward, sideways, up and down or backwards. In this way the hand or the whole arm can follow this pattern up and down.

Gross motor examples of this type of series included making figure eights, first by simultaneously pairing the movements in the same direction and then changing the direction, and finally going in opposite directions. The continued focus on using a rhythmic count of eight for each step, will be used to help students anticipate what will come next. Additional gross motor skills utilized the entire body. Children went from a split to a squat stance, first in unison with the video. Then they were encouraged to go in opposite directions, so when the instructor on the video jumped sideways, the participants were encouraged to squat. These series as well as others were done several times throughout the four weeks, first very slowly and then repeated faster so the child would have added familiarity with the sequences.

The six-minute video segments were shown each day after the children had been sitting for at least 20 minutes. This meant that they did not get the activity at the same time each day, but that they did get it during a time when they had been sedentary for at least 20 minutes. This was done for four weeks, though the teacher reported missing 3 days.

Fitbit Challenge. The Fitbit Challenge is a series of challenges designed to be used in conjunction with wearing the Fitbit. During the first week of the intervention, the students were encouraged to increase their steps each day by 2,000, with the goal of reaching at least 10,000 steps a day. In week 4 the challenge was to guess how many steps the class would take, based upon the student's own steps. Group totals were reported to the teacher and shared with the class. The goal that week was to increase the individual classroom totals. In week 5, students were asked to monitor how far they could walk (distance traveled on the Fitbit) and use that to make an estimate for the group. The goal for the total distance was to cross Michigan. During week 6, the focus shifted to climbing mountains (stairs): students were encouraged to set an individual goal and to estimate a class goal. Each Monday, the classroom totals were sent to the teacher, highlighting the previous week's goals. Students were encouraged but not required to do any of the Fitbit Challenges.

Measurements

D2 Test of Attention. Prior to the beginning of this study, teachers were consulted about what they would like to see tested. Teachers noted as being important: (1) minimize the amount of time spent on testing and (2) show gains in attention and concentration. The d2 Test was chosen for three reasons. It measures both visual processing speed and ability to concentrate, it is easy to use and it only takes up a very short time to administer (approximately 8 minutes). The d2 Test is a cancellation test of attention and concentration, which has been shown to be an internally valid measure of scanning accuracy, speed, discriminant validity and fluctuation across trials (Bates & Lemay, 2004; Davis & Zilllmer, 1998). The d2 Test is meant to assess the child's capacity to focus on one stimulus, while ignoring or suppressing others (Brickenkamp & Zillmer, 1998). The standard version of the d2 Test of Attention allows the participants 20 seconds per line to selectively identify the letter "d" with two dashes, either above, below or one dash on top

$$\ddot{d} \qquad \underset{\cdot\cdot}{d} \qquad \underset{\cdot}{\dot{d}}$$

of the "d" one on the bottom. Distractors come in two forms, more or less dashes above or below the "d", and the letter "p" with two dashes, which was chosen based upon its similarity to the letter "d" (Brickenkamp & Zillmer, 1998).

The d2 test measures executive function using attention and concentration. These can be broken down into subcategories that are measured by the d2. Concentration performance (CP) measures selective attention, which is the ability to attend to stimuli while disregarding other irrelevant tasks (Brickenkamp & Zillmer, 1998). Total number (TN) of items processed relates to the processing speed, while processing accuracy is the total number of items minus the total number of errors (TNE). Errors of omission (not selecting a d2) and errors of commission (selecting a distractor) were used to calculate the accuracy score (E%). Finally, fluctuation rate (FR) measures individual's ability to maintain concentration over an extended period of time, also called sustained attention (Brickenkamp & Zillmer, 1998).

Fitbits. Fitbit Charge Heart Rate monitors (Fitbits) were given to both classes in the intervention school. Fitbits are devices that use a non-invasive wireless sensor on the wrist to measure heart rate. The Fitbit relies on an accelerometer to measure steps and calculates distance traveled. It also calculates a measure of sedentary, low to moderate, and moderate to vigorous physical activity using physiological measure of energy cost, the Metabolic Equivalents (METs)

(WHO, 2015). The Fitbits are user-friendly and have been shown to be both reliable and valid for step count (Kooiman et al., 2015) and energy expenditure (Lee, Kim, & Welk, 2014).

Before the students were given the Fitbits, they were given and read instructions regarding the care and maintenance of the device (see Appendix A). They were also told again the reason why they were wearing the Fitbits. Children were then taught about each aspect of the Fitbits: how to determine how many steps, how far they had gone, the number of calories they burned, and the heart rate, as well as the number of floors they had climbed. Children were told that they should try to wear the Fitbits Monday through Friday at all times, except when showering or in the likelihood of getting really wet. Children were also told that they would not get in trouble if they took them off, but were encouraged to wear them as often as possible.

The Fitbits were then given to the students and the teacher and researcher helped put them on. Once they were on, they were told about the timer function and the fact that the Fitbits would buzz if they made it to 10,000 steps. Students in the PAEB-C group were then given the Fibit Challenge worksheets to take home and record their daily steps throughout the four weeks. Both teachers were encouraged to talk about the Fitbits and to share weekly reports with the kids. They were also both given a Fitbit to wear if they wanted to model the behavior but their information was not recorded. Additionally, the physical education teacher (who has her own Fitbit) was encouraged to get the kids to think about their steps, distance traveled, and heart rates in their gym class, which was held twice a week.

On each Friday during the four weeks of the intervention, students were asked to place their Fitbits on the charger before they left for home on the weekend. After students had left school, the researcher went to the schools and uploaded the information from the Fitbits onto a secure Fitbit Software database, Fitabase (Small Steps Lab, 2015). This is a password-protected site, accessible only by the researchers and the data management team from Fitabase. The researcher recorded which Fitbits had been placed on the charging station and reported missing devices to the teacher. Teachers were encouraged to read off these numbers in class as a way to remind students to bring the Fitbits in on Fridays so that the data could be recorded. Teachers were also given printouts of the classrooms totals for the week as well as daily averages, steps, distance, and stairs to share with the class on Monday. Students were encouraged to think about how they had contributed to classroom totals and where they fell with regards to the averages. Fitbits were collected after students wore them four weeks Monday through Friday.

Data Collection. On October 21st (Fitbit-O and PAEB-C) and October 26th (comparison) students began the pretesting. Once they completed the test, students in the two intervention groups were given their Fitbits and were encouraged to wear them Monday through Friday. On November 17th (PAEB-C and Fitbit-O) and November 26th (Comparison) the students took the post-test. At this time, students in both Fitbit groups were asked to fill out a 5-point Likert style survey, which asked five questions about wearing the Fitbits. Pre- and post-test data entry was completed by January 2016. SPSS was used to merge the data.

Data Analysis

The data analysis for the d2 Test was based upon the guidelines set by Brickenkamp and Zillmer (1998). The TN, TNE, FR, E%, and CP were calculated for each student's pre- and post-test. All statistical analyses were conducted by means of IBM SPSS statistics version 22 for Windows. Change scores were calculated for each of the dependent variables to measure change over time. A repeated measure MANOVA was utilized to identify significant change and group differences in change over time while controlling for gender and minority status. For significant effects, a repeated measure ANOVA was run to examine the mean differences in each dependent variable among three groups at a time, again controlling for race and gender. Finally, a post hoc comparison was performed to examine the mean difference in each dependent variable between two groups (i.e., PAEB-C vs Fitbit-O; PAEB-C vs comparison; and Fitbit-O vs comparison). A significant level of $p < .05$ was set for all statistical methods.

Results

Table 3.1 presents the descriptive statistics for the d2 Test variables at pre-and post-tests. There were no significant differences between the two intervention groups on the d2 Test ($p = .23$) at pre-test. Significant differences were found on the post-test in E% ($p = .042$), Fluctuation Rate ($p = .012$), and Concentration Performance ($p = .000$) (see Table 3.2).

Table 3.1 Descriptive Statistics and Results for PAEB-C, Fitbit-O and Comparison Groups Pre- and Post-test Measures.

	PAEB-C (N=31)		Fitbit-O (N=28)		Comparison (N=55)	
Variable	M	SD	M	SD	M	SD
Pre-test						
Processing Speed (TN)	271.68	38.99	278.79	49.46	317.7	66.37
Focused Attention (TNE)	250.84	41.81	257.29	48.28	293.02	61.67
Accuracy (Error %)	7.15	7.72	8.96	9.06	7.19	10.1
Concentration Performance (CP)	93.65	26.57	94.11	25.23	112.58	34.04
Attention Span (FR)	17.32	7.021	14.86	5.82	14.77	7.27
Post-test						
Processing Speed (TN)	362.65	76.27	357.14	73.36	374.18	82.18
Focused Attention (TNE)	353.03	77.16	336.86	67.66	350.55	82.83
Accuracy (Error %)	2.74	3.55	6.47	9.24	4.34	7.83
Concentration Performance (CP)	138.68	29.68	109.93	33.95	133	34.95
Attention Span (FR)	14.39	7.19	18.90	9.89	17.87	8.54

When examining the Fitbit school against the comparison school (see Table 3.3), independent t tests showed that CP ($p = .04$), TN ($p = .01$), and TNE ($p = .001$) were significantly higher in the comparison school at the pretest. During the post-test, there were no longer significant differences between the two groups, but FR were lower in the intervention

Table 3.2 Independent Samples Test between the PAEB-C and Fitbit-O Groups

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Pre-test FR	1.448	.234	1.422	55	.081	2.463	1.732	-1.007	5.933
Post-test FR	3.729	.059	-2.315	56	**.012**	-5.302	2.290	-9.891	-.714
Pre-test E%	1.267	.265	-.924	55	.180	-1.93	2.09	-6.11	2.25
Post-test E%	9.696	.003	-1.761	56	**.042**	-3.07	1.74	-6.56	.422
Pre-test CP	.000	.997	.095	55	.463	.648	6.847	-13.074	14.370
Post-test CP	.023	.881	3.481	56	**.001**	28.540	8.199	12.116	44.965
Pre-test TN	.476	.493	-.555	55	.291	-6.515	11.741	-30.044	17.014
Post-test TN	.363	.549	.226	56	.411	4.519	20.021	-35.589	44.627
Pre-test TNE	.444	.508	-.519	55	.303	-6.200	11.945	-30.138	17.738
Post-test TNE	1.450	.234	.666	56	.254	12.852	19.291	-25.792	51.497

Table 3.3 A repeated measure MANOVA: Comparing overall differences in the scores from pre- to post-test across the three groups.

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Pre-test FR	.000	.998	.836	112	.203	1.088	1.301	-1.491	3.666
Post-test FR	.615	.435	-1.902	113	**.030**	-2.988	1.570	-6.099	.124
Pre-test E%	.692	.407	-.057	111	.478	-.10	1.75	-3.56	3.36
Post-test E%	.624	.431	-.303	113	.382	-.42	1.40	-3.19	2.35
Pre-test CP	2.368	.127	-2.944	111	**.002**	-16.783	5.701	-28.081	-5.485
Post-test CP	.126	.723	-.883	113	.190	-5.740	6.503	-18.624	7.145
Pre-test TN	4.658	**.033**	-4.058	111	**.000**	-42.644	10.508	-63.466	
Post-test TN	.084	.773	-.933	113	.177	-13.668	14.654	-42.699	15.364
Pre-test TNE Post-test TNE	2.721	.102	-3.574	111	**.001**	-36.275	10.149	-56.386	- 16.164
	.035	.851	-.571	113	.285	-8.322	14.570	-37.187	20.543

school (p = .030). This suggests that PAEB-C group was more consistent in their focus even though it was not significantly different when comparing the three groups. Neither gender nor minority status (both measured dichotomously) were found to be significantly related to the d2 test of attention.

A repeated measured MANOVA (see Table 3.4) revealed a significant difference between subjects across the three groups (p < .000). It also revealed a significant effect of time (F=10.995, p=.000) (pre-to post-test), indicating an overall increase from pre-to post-test for all three groups (F=3.416, p=.000). In addition, the interaction pre/post and study groups was significant (p < .000), indicating difference in the rate of change for the three groups. When covariates were included, the effect remained significant but the covariates were not significant (race: F = .995, p = .440; gender: F = 1.012, p = .440).

Table 3.4 A repeated measure MANOVA: Comparing overall differences in the scores from pre-to post-test across the three groups.

Effects		F	df	Error df	Significance
Between Subjects	Intercept	273.471	7	102	.000
	Minority	1.160	7	102	.332
	Gender	1.488	7	102	.180
	Three Groups	1.561	14	204	..097
Within Subjects Tests	Pre to Post	10.995	7	102	.000
	Pre to Post * Minority	.995	7	102	.440
	Pre to Post * Gender	1.012	7	102	.440
	Pre to Post * Three Groups	3.314	14	204	.000

A repeated measure ANOVA analysis was run comparing the change from pre-to post-test scores in the three groups (see Table 3.5). Four of the dependent variables were found to be significantly different: processing speed (F = .37, p = .038), focused attention (F = 4.37, p = .015), concentration performance (F = 13.53, p = .000), as well as attention span (F = 8.04, p =

.001) (See Table 3.4). This suggests that increase in processing speed, focused attention, and concentration performance were associated with the intervention. Additionally, fluctuation rate scores decreased significantly [more pronounced] for students in the intervention group, which points to a more consistent attention span throughout the testing procedure.

Table 3.5 A repeated measure ANOVA: 3 (PAEB-C, Fitbit-O, Comparison) x 2 (Pre-Test, Post-Test) on processing speed, focused attention, accuracy, concentration performance and attention span.

Measure	F	df	p	R^2
Processing Speed (TN)				
Time (Pre- to Post-test)	140.52	1	.000	.561
Time*3 Groups	3.372	2	.038	.058
Focused Attention (TNE)				
Time (Pre- to Post-test)	193.44	1	.00	.637
Time*3 Groups	4.37	2	.015	.074
Accuracy (Error %)				
Time (Pre- to Post-test)	21.35	1	.000	.163
Time*3 Groups	.194	2	.824	.004
Concentration Performance (CP)				
Time (Pre- to Post-test)	160.14	1	.000	.593
Time*3 Groups	13.53	2	.000	.197
Attention Span (FR)				
Time (Pre- to Post-test)	2.71	1	.102	.024
Time*3 Groups	8.04	2	.001	.128

A post hoc comparison was run to test the differences in each of the dependent variables in which significant results in the ANOVA were found, group by group. Since accuracy (E%) was not found to be significant, it was not evaluated in the post hoc comparison. The results of the post hoc comparison indicated that there continued to be significant differences in CP (F = 24.162, p = .000) and FR (F = 6.891, p = .011) when comparing only the PAEB-C and the Fitbit-O conditions, meaning that students taking part in the PAEB-C were better able to concentrate and sustain attention after the intervention (see Table 3.6). No differences were found between the Fitbit-O and the comparison groups. Significant differences were found between the PAEB-C group and the comparison group in all of the dependent variables TN (F = 6.88, p = .010), TNE (F = 10.69, p = .002), CP (F = 26.46, p = .000), and FR (F = 14.09, p = .000). These differences highlight a positive change over time in attention and concentration performance in the intervention group matched with the comparison group. No significant differences were found between the Fitbit-O and comparison groups in executive function from pre-to post-test.

Table 3.6 A Post hoc comparison: 2 (PAEB-C, Fitbit-O) x 2 (Pre-Test, Post-Test), 2 (PAEB-C, Comparison) x 2 (Pre-Test, Post-Test) and 2 (Fitbit-O, Comparison) x 2 (Pre-Test, Post-Test) on the dependent measures of processing speed, focused attention, concentration

Pre to Post Measure	df	Mean Square	F	p	R^2
Processing Speed (TN)					
PAEB*Fitbit-O	1	1994.83	.925	.340	.016
PAEB*Comparison	1	12811.002	6.876	.010	.076
Fitbit-O*Comparison	1	3521.045	1.842	.178	.022
Focused Attention (TNE)					
PAEB*Fitbit-O	1	3371.190	1.73	.194	.029
PAEB*Comparison	1	16320.026	10.688	.002	.113
Fitbit-O*Comparison	1	3408.357	1.874	.175	.023
Accuracy (E%)					
PAEB*Fitbit-O	1	10.802	.538	.466	.010
PAEB*Comparison	1	10.627	.297	.587	.004
Fitbit-O*Comparison	1	.026	.001	.976	.000
Concentration Performance (CP)					
PAEB*Fitbit-O	1	4835.634	24.162	.000	.298
PAEB*Comparison	1	6429.939	26.454	.000	.240
Fitbit-O*Comparison	1	.271	.001	.976	.000
Attention Span (FR)					
PAEB*Fitbit-O	1	262.277	6.891	.011	.108
PAEB*Comparison	1	568.329	14.090	.000	.144
Fitbit-O*Comparison	1	23.769	.568	.453	.007

Students who took part in the PAEB-C increased their scores significantly in four areas of attention and concentration over the comparison group. No change was found that indicated an improvement in error percentage. Similar to the multivariate analysis, no gender or race effects were found between the groups. The results support the hypothesis that short six-minute sessions of coordinated bilateral activities in a classroom over the course of four weeks improve attention and concentration scores for students. The results suggest there are significant improvements for the PAEB-C group on four constructs when all three groups were compared.

Discussion

In schools, increased class sizes, increased workload, and shorter breaks make it harder for teachers to keep children on task (Blatchford, Bassett, & Brown, 2011). When children are less engaged, children may fall behind academically. Falling behind can lead children to be more likely to exhibit increased behavioral problems alongside the already problematic decreases in academic successes (NIMH, 2015). If a child lacks the ability to sustain attention development of further executive functions and metacognition may be hindered (Halperin & Healey, 2011). This study supports the idea that adding short coordinated physical activity breaks into the classroom routine can helps children sustain and sharpen their attention. By helping children find a way to better engage and attend to their learning, schools may be able to reduce future problems of self-control and thus improve academic outcomes for all students (Healy, 2004).

This study examined the effects of four weeks of coordinated bilateral activities and a Fitbit Challenge on the attention of fifth grade elementary students. As expected, the students in all three groups showed improvements from pre-to post-test on the d2 Test of Attention (Brickenkamp & Zillmer, 1998; Budde et al., 2008; Gallotta et al, 2012; 2015). The literature also suggested that additional physical activity is effective at improving attention (Budde et al., 2008; Galootta et al., 2012; 2015; Schmidt et al., 2015; Van Dijk et al., 2014). This too was supported by the findings in this study. Differences, however were found between the specific findings in other studies based upon the d2 test variables. Budde et al. (2008), in their coordinated physical education intervention found improvements in processing speed (TN), focused attention (TNE) and accuracy (E%), but they did not see improvements in concentration performance (CP) or attention span (FR). Schmidt et al. (2015) and Gallotta et al. (2015) both reported significant differences in TN, E%, and CP, but not in TNE or FR. Both used coordinated activities and found the most significant differences were highest 90 minutes after exercising. Schmidt et al (2015) focused on time delay, while Gallotta et al. (2015, 2012) found the most significant differences were highest during aerobic exercise. Significant results also were found with academic lessons and coordinated physical activity interventions (Gallotta et al., 2015, 2012). In this study, we found that the PAEB-C students improved significantly compared to the comparison group in processing speed (TN), focused attention (TNE), concentration performance (CP) and attention span (FR), but not in accuracy (E%) ($F = .076$, $p = .784$).

Like Schmidt et al. (2015), who used cognitively demanding physical activities, this study relied on the PAEB fine and gross motor movements to keep the students thinking while they were taking part in the physical activities. The PAEB used timing sequences and repetitive patterned movements to engage both hemispheres of the brain. Therefore, the removal of the academic components may have had less significance, since students were continuing to facilitate exchange of information between the cerebellum and prefrontal cortex by focusing on their movements and movement sequences (Diamond, 2015; Pedersen, 2014). Additionally, since these movements were purposeful, as seen in Pederson (2014), this study was able to expand upon the notion of improved motor processing leading to improved cognitive development.

In addition to improvements for PAEB-C group and the comparison group, the PAEB-C group also showed improvements compared to the Fitbit-O group for CP and FR. This adds merit to the idea that adding specific physical activities to the school day versus just adding a Fitbit may improve executive function. But it also suggests that even non-focused activities brought about by wearing the Fitbit may potentially affect a student's executive function. This is highlighted by the lack of difference between TN and TNE in the two intervention groups where differences did exists between the comparison group and the PAEB-C. This may be explained by the partial intervention effect of wearing the Fitbits. Students in this group may have been more active throughout the study compared to the Comparison group. However, physical activity data are not available for the Comparison group to showcase this. Results are available from study 2, which may help to clarify the lack of significance of TN and TNE. In this study, the PAEB-C and the Fitbit-O students saw improvements in their fitness from pre-to post- fitness assessments when tested against the comparison test. Since aerobic capacity comes into play in the fitness assessments, it suggests that both groups were taking part in more aerobic physical activity outside of the intervention than the comparison group. The results from Schmidt et al. (2015) support this theory, since they found the most significant results came from students who took part in highly aerobic activities. However, in this study, the resulting difference was not enough to show that wearing the Fitbits significantly improved processing speed or accuracy by itself, evidenced by no significant results when the post hoc analysis was run between the Fitbit-O and the comparison group (Table 3. 5).

This study highlights that the six-minute PAEB videos can be a feasible alternative for adding physical activities in the classroom context. Since the activities get faster and become more complex, they may be appropriate for use in the classroom for extended periods of time. As they are videos, and do not require additional space, they can easily be run by the schools without the assistant of a researcher. McClelland, Pitt, and Stein (2015) highlighted the importance of students being able to do and feel comfortable doing the physical activities. In this intervention, students were taught how to do the activity, first very slowly. As they became comfortable, more complex activities were built in each week. Like McClelland, Pitt, and Stein (2015), who found significant positive improvements in national results of reading, writing, and math, at the conclusion of our study students performed better on attention and concentration measures.

Finally, the concept that coordinated physical activities act to facilitate arousal of the brain and that they may be influential in brain development is the final component that should be discussed (Hung et al., 2013). Budde et al. (2010) suggests that changes in the brain occur from steroid enhancement triggered by exercise. Tomporowski (2003) suggests that this may be due to increased blood flow. Hung et al. (2013) attribute the changes to brain-derived neurotrophic factors (BDNF) and Smith, Goldsworthy, Garside, Wood, and Ridding (2014) to brain plasticity. Regardless of the underlying neurological mechanism, this research supports the notion that physical activity, particularly coordinated bilateral activities in short increments improve attention and concentration. This research further extends the literature demonstrating that regular physical activity has a positive impact on executive functions (Rasberry et al. 2011; Van der Fels et al., 2015). Furthermore, it brings attention to the possibility that adding coordinated bilateral activities, which can be performed in a regular classroom with limited space, may be a feasible alternative to academically based physical activity lessons, while still having some of the same benefits. Future studies may want to consider adding both focused sequenced coordinated activities alongside academic lessons into the classroom to see if there is a significant difference between the two strategies.

Limitations

This study has several limitations, which relate to the generalizability of the data. The first is that the schools were convenience samples, with the Fitbit school self-selecting to be in the study. Moreover, two other schools may have matched the intervention school better by race and by social economic status, but they were both eliminated because they were involved in other interventions within the district. This may account for the higher baseline d2 scores found in the comparison school.

On the advent of the program one teacher in the Fitbit school chose not to take part in the Fitbit Challenge, which changed the interaction between the groups. As a result it is difficult to be certain that the improvements on the d2 were directly the result of the PAEB activities. Since the classroom took part in a Fitbit Challenge as well as the PAEB activities (where as the second intervention group did not do the Fitbit Challenge), it is possible that this confounded the study results. There is no way to be sure it was not the Fitbit Challenge that caused the changes and not the PAEB activities. A study that looks only at the three conditions, PAEB, Challenge and comparison groups would allow for a better understanding of the causal relationship.

Additionally, after the completion of the study, the PAEB teacher reported that she showed 17 out of 20 of the PAEB videos. She also reported that she did not check up on any of the Fitbit Challenges as a class. Therefore, if students in the Fitbit Challenge completed the Challenge worksheet they did so primarily on their own. Future studies may want to consider the impact of using the Fitbit alone compared to a more intensive Fitbit Challenge. These studies could examine if there are differences in self-initiated activity compared to a classroom challenge meant to encourage the child to be more active, and improvements in executive functions. In a future study more emphasis should be placed on checking in with students about the results of the Fitbit Challenge to see if the challenge itself can be used to facilitate improvements in overall d2 scores.

Conclusion

The current findings support previous literature that demonstrates that a positive relationship exists between classroom-based physical activities and improved attention (Budde et al., 2008; Galootta et al., 2015; Galotta et al., 2012; Schmidt et al., 2015; Van Dijk et al., 2014). However, this study used a novel approach, which eliminated the academic components seen in other studies and focused solely on coordinated bilateral activities to highlight the positive effect on attention and concentration. It demonstrated that over the course of four weeks, there were improvements for the students who were exposed to the PAEB and Fitbit Challenge. This effect was stronger in contrast to the comparison group than with students in the Fitbit-O group. This suggests that the effect of the PAEB-C intervention may also be impacted by increased physical activity levels brought about by use of the Fitbits in the Fitbit-O group. The design, however, does not allow the researcher to investigate the role that the Fitbit Challenge, or activity increases from the Fitbit, might have had on the children's d2 scores. Therefore, further research is needed to further elucidate that relationship.

Chapter 4

Impact of a Technology-Enhanced Intervention on Physical Activity Levels and Health-Related Fitness Zones in School-Aged Children

Abstract

Continued efforts to improve children's physical activity and fitness levels alongside improvements in core subject areas in schools is driving a new thread of research. The relationship between physical activity, fitness, and executive function has received a lot of attention as a result of these efforts. This study compared a Fitbit only (Fitbit-O) (N=29), a physical activities engaging the brain (PAEB) + Fitbit Challenge (C) and a comparison group (n=56) to see if the addition of Fitbits (N=31) improved fitness, steps or activity minutes. A repeated measured MANOVA and post hoc were used to calculate changes in fitness levels. Total and mean scores for steps and (sedentary, low, fairly, high) activity minutes were also compared using an ANOVA. The PAEB-C students averaged 2206 more steps/day than the Fitbit-O group, and were less likely to be sedentary. Both Fitbit groups saw greater increases in their Fitness scores than the comparison group from pre-to post-test. No gender differences were found at baseline for fitness, but boys in the PAEB-C group showed significant improvement in very high ($p=.014$, F3.923) and fairly active ($p=.007$, $F=11.825$) minutes. Pre-test fitness results were paired with d2 test results and were directly correlated to TN, TNE, CP, and FR ($p < .01$). This study is an easy to run, minimal contact intervention that can be used to improve physical activity and fitness in the classroom.

Introduction

Children spend a large percentage of time in a school environment that is most often sedentary (McNeely & Blanchard, 2015). But schools can be a good place to incorporate daily physical activity into a child's routine (Carlson et al., 2015). As budgets are cut for recess monitoring and physical education (Barroso, McCullum-Gomez, Hoelscher, Kelder, & Murray, 2005), the classroom may prove to be an excellent context to include physical activity. Since much of the effort and budgets in schools have been geared towards improving core subject matter (Marin & Murtagh, 2015), adding even a little daily physical activity into the classroom may become important to offset physical inactivity in children (Blair, 2009). This study added two easy to run intervention strategies PAEB-C and Fitbit-O as a way to increase physical activity and fitness.

Background

The Centers for Disease Control (CDC) recommends that children should get 60 minutes or more of moderate to vigorous physical activity (MVPA) a day. Research continues to reveal the many ways in which physical activity benefits individual health ranging from improved cardiac performance to improved mental health (CDC, 2015). Ploughman (2008) suggests that MVPA is important for children and adolescents whose brains are changing rapidly. But adults and children in America are not engaging in the recommended MVPA. One in three adults does not take part in the recommended amount of MVPA per week (DHHS, 2010), and one in three children does not take part in the recommended amount of physical activity per day (NASPE, 2009). Not only are the levels of actual MVPA lower than recommended levels, but children now spend more time being sedentary, averaging approximately seven and one half hours in front of a television, computer, or videogame per day (Rideout, Foehr, & Roberts, 2010). A cross sectional study done by the National Health and Nutrition Examination Survey (NHNES) (Pate et al., 2006) found that one out of three individuals failed to meet cardiorespiratory fitness standards. Since physical activity increases academic performance (Sallis, Prochaska, & Taylor, 2000), it stands to reason that more effort should be made to improve the physical activity levels of children.

Adding physical activity to the classroom is a new approach towards improving physical activity levels and fitness in schools (Carlson et al., 2015; Fedewa, Ahn, Erwin, & Davis, 2015; Mahar, Murphy, Rowe, Goldern, Sheild and Raedeke, 2006; Marin, & Murtagh, 2015; Reznik, Wylie-Rosett, Kim, & Ozuah, 2015). Carlson et al. (2015) found that ten minutes breaks in addition to other activity breaks (physical education and recess) significantly increased the likelihood of obtaining 30 minutes per day of physical activity during school. Similarly, Mahar et al., (2006) added "energizers" (academically based physical activities) to increase physical activities in the classroom. They found that the number of steps taken during school were significantly increased in the intervention groups compared to the control students (Mahar et al., 2006). Fedewa et al. (2015) found that adding twenty minutes of daily physical activity to the classroom, in addition to increasing the steps between the control and experimental school, was also influential in reducing the seasonal step decreases found during winter. Despite measuring physical activity, however, none of these studies measured fitness after the classroom-based intervention, which is highlighted as a limitation in the Fedewa et al. (2015) study.

This study investigated whether Fitbits were able to facilitate a change in fitness between three groups and whether the improvements of fitness had a direct correlation with improvements in attention and concentration. Studies have generally shown positive associations between cognitive performance during acute bouts of physical activity (Brisswalter, Collardeau,

& René, 2002; Budde, Voelcker-Rehage, Pietraßyk-Kendziorra, Machado, Ribeiro, & Arafat, 2010; Hillman, Pontifex, Raine, Castelli, Hall, & Kramer, 2010; Kashihara, Maruyama, Murota, & Nakahara, 2009; Tomporowski, 2003), as well as memory, attention, and speed of reaction (Pesce, Crova, Cereatti, Casella, & Bellucci, 2009; Sibley & Etnier, 2003). Several studies have found significant correlations between physical activity and executive function, or specifically, assessed individuals using the d2 test (Budde, Voelcker-Rehage, Pietrassyk-Kendziorra, Ribeiro, & Tidow, 2008; Gallotta et al., 2015; Gallotta et al., 2012; Ma, Le Mare, & Gurd, 2015; Schmidt, Egger, & Conzelmann, 2015).

However, very few of these studies kept track of fitness or physical activity steps in addition to the measurements for executive function. For example, Gallotta et al. (2012) found that attention and concentration was positively affected by the introduction of ten minutes of physical activities of varied exertion and coordination levels, but they did not track activity or fitness**.** Howie et al. (2014) studied the ideal time of the intervention breaks and found that five minutes was not enough, but that ten and twenty minute classroom breaks showed the most significant improvements, but again no measurements were used for physical activity or fitness.

Schmidt et al. (2008) used three administrations of the d2 Test. They tested the students once before an intensive bout of coordinated physical activities, once directly after, and a final time 90 minutes later. Results of the three d2 tests were compared to a control group who sat for the entire lesson. All the physically active groups showed improvements compared to the control group. However, statistically greater increases were found in focused attention and processing speed 90 minutes after the activity was completed (Schmidt et al., 2008). Although they did not measure fitness, this study suggests that benefits of the short bouts of physical activity have a longer impact than just at the acute level, because the best results were found 90 minutes later.

This gives merit to measuring fitness levels to see what impact they have beyond acute physical activity.

Several studies did add measures for physical activity or fitness, but they did not track attention and concentration, nor were they implemented in a classroom setting. In a study integrating Funtervals (high intensity academic breaks), Ma et al. (2015) found that they increased physical activity levels with the addition of only four minutes a day, but again they did not assess fitness as an outcome variable. A cross sectional study done by Van der Niet et al. (2014) found that there was a relationship between executive functioning (Tower of London and Trailmaking tests), academic achievement, and fitness. Executive functioning was the strongest predictor of success, but the researchers did not introduce additional physical activity to the school day (Van der Niet et al., 2014). Similarly, Booth et al. (2014) used accelerometers to objectively measure children's every day physical activity alongside the Test of Everyday Attention for Children (TEA-Ch). In this study they document improvements based on MVPA levels for attention, but they also did not measure fitness. Children (11-13 years old) were more likely to have positive results when they were more physically active, which was more pronounced in males.

When accelerometers were added to determine physical activity levels in association with several cognitive and academic measures by Van Dijk, De Groot, Savelberg, Van Acker and Kirshner (2014), including the d2 Test of Attention, the evidence was inconclusive. Though there were direct positive associations between total physical activity and attention and concentration, the relationship to academics was not as clear. The highly active 14-year olds did academically better than the highly active 12 years olds. It is speculated that this was for two reasons. First, adolescence is a difficult time of transition for children, and second, the younger group coincides with a time of new academic and social challenges in school (Eccles, & Midgley, 1989). Therefore, children who are very busy may struggle at first with time management, balancing new homework challenges and extracurricular activities, but after the initial trials they then cope better than their more sedentary counterparts (Van Dijk et al., 2014). According to a cohort profile of the research (de Groot, van Dijk, & Kirschner, 2015), fitness data (20 m shuttle run) was collected but no significant relationships were reported between fitness and executive function. Yin and Moore (2004) found that as students entered middle school, test scores decreased if they were involved in after school physical activities. Nevertheless, even in this study, these differences disappeared with continued participation, by the time the children were in 10th or 12th grade. An important distinction in these three studies is that none of them looked at classroom-based physical activities. This may support the idea of adding physical activity to the day during times of transition, where it will not directly compete with academic work done outside of the classrooms or after school. Since, schools continue to cut physical education classes (Chaddock, Pontifex, & Hillman, 2011), finding a way to keep kids active and to increase fitness during the day may be a better alternative than relying on kids to find the time outside of school.

To understand why we should still add physical activity to the day as a way to bolster academics, it is also important to understand the relationship between physical activity and the brain. When considering an individual's brain function and brain health, the biggest factors affecting academic performance relate to an individual's levels of fitness and capacity to do MVPA (Thomas, Dennis, Bandettini, & Johansen-Berg, 2012). Evidence continues to suggest that decreasing physical activity levels impairs neuro-cognition (Thomas et al., 2012). In a review article, Chaddock et al. (2011) point to improvements in hippocampal functioning (spatial memory) and basal ganglia (stimulus response centers) control through moderate physical activity. Higher fit individuals have also been found to experience neurogenesis, or development of brain-derived neurotrophic factors (BDNF), which can potentially mediate the other brain related effects (Szuhany, Bugatti & Otto, 2014). Negative associations abound with lower fit children, who experience decreased inhibitory control or smaller dorsal striatum than their fitter counterparts (Chaddock et al., 2011).

In addition to improvements of the brain structure, functional improvements related to aerobic capacity have also been studied with relationship to event-related potentials (ERPs) (Gomez-Pinilla, & Hillman, 2013). ERPs measure the response of the brain to specific motor events. Chaddock et al. (2011) hypothesized that the aerobic fitness of an individual mediates the relationship between the neurocognitive process of motor stimulus engagement and execution in young preadolescent children (Hillman et al., 2005, 2009; Pontifex et al., 2010). Buck, Hillman, and Castelli (2008) demonstrated this concept by looking at aerobic fitness and executive control by way of the Stroop test. In their study, greater aerobic fitness was associated with better performance in executive control in children 7- 12 years old. (Buck, Hillman, & Castelli, 2008). Additional studies that assessed aspects of the neuroelectric functions of the brain continue to support the concept that lower fitness levels are associated with poorer cognitive integrity and a decreased ability to allocate attention and process information (Chaddock et al., 2011).

Better cognitive performance in people with higher levels of fitness was also assessed by using a response inhibition test, or Flanker task, which tests participant’s skill to suppress spontaneous but incorrect responses. Hillman et al. (2009) found that higher fit children had fewer errors and were more accurate when tested than their lower fit peers, but found no differences in reaction time. Similarly, Wu, Pontifex, Raine, Chaddock, Voss, Kramer and

Hillman (2011) studied pre-adolescents and found positive associations between level of fitness and Flanker test performance. Additionally, they found a more steady response time and higher accuracy with students who were rated in the high fit category. Although this study was limited by being a cross sectional, and the small scale activity in the Hillman et al. (2009) study, they both support the concept that children who engage in regular physical activity, and thus are more fit, will see benefits related to brain health and function.

Van der Niet, Smith, Scherder, Oosterlaan, Harman and Visscher (2015) looked at children aged 8-12 and found that children who spent more time in sedentary behaviors showed detriments to inhibition, while those with a higher total volume of regular physical activity had a higher capacity for planning and for task completion. This was further improved in subjects with higher levels of MVPA. Van der Niet et al. (2015) called for more studies that look at physical activity levels in relationship to cognitive function.

Research Purpose and Hypotheses

The purpose of this study was to examine the addition of two intervention strategies on physical activity levels, fitness and executive function. The study has three hypotheses. First, we hypothesize that the everyday activity levels will be higher for students in the PAEB-C group than the Fitbit-O. Second, we predict that participants in the Fitbit groups will see a greater pre- to post- improvement (change in) fitness levels relative to the control group. We also predict the PAEB-C intervention group will increase their fitness compared to the Fitbit-O condition. Finally, we predict a positive correlation between fitness and attention measures.

Methods

Recruitment

Institute for Review Board approval was obtained from the University of Michigan (HUM00102732). 116 fifth grade students were recruited from two Southeast Michigan Title 1 schools. In order to recruit participants for this study, information letters were sent home from school. In addition to information about the study, the letters were sent with permission slips to be returned to the school if children wanted to participate in the study (Appendix C). These letters were sent home a second time, if students failed to return with a permission slip by the end of the week. Before students were administrated the d2 test of attention they were asked to sign a written consent form, which was read aloud (Appendix D). Between 87.7% (Comparison) and 96.9% (PAEB-C) of those approached signed permission slips.

Sample

This study was conducted with the intention to match the population of Gallotta et al's (2012, 2014) studies. The intervention school was chosen because the physical education teacher reached out to the University upon hearing about the study. The comparison school was selected based upon similarities and proximity to the intervention school. Parents were sent home a copy of the study guidelines one week prior to being sent a consent form. Parents' consents were secured for the study prior to asking consent of the children.

This study used a quasi-experimental design to assign comparison (N = 56) and experimental (N=60) groups. The researchers assigned two classes in the experimental school to intervention conditions: Fitbit-only (Fitbit-O) (N = 29) and a group that used the Physical Activities to Engage the Brain plus a Fitbit Challenge (PAEB-C) (N = 31). The study took seven weeks. The first week was used for recruitment, the second and the last weeks for testing the children, while the four weeks in the middle were used for the interventions. All three groups took part in pre-and post-fitness assessments as well as pre-and post-tests of the d2 Test of Attention (d2 test). A total of 114 students took both the pre-and post- d2 test, and 113 took both of the fitness assessments. The study obtained baseline and post- fitness assessments using two aerobic fitness assessments to calculate the child's Health-Related Fitness Zones (HRFZ). These were the one mile walk/run fitness assessment and the Progressive Aerobic Cardiovascular Endurance Run (PACER).

Procedure

In the two experimental groups, physical activity data were obtained using Fitbit Charge Heart Rate monitors. The Fitbits were given to the students to wear for four weeks with an assigned number. In addition, the PAEB-C group took park in six minutes of coordinated bilateral activities shown on a video. The classroom teacher played the videos during the first part of the day when the kids had been sitting for longer than twenty minutes. This meant that students did not get the intervention at exactly the same time each day, but that they got it during a time when they had been sedentary for at least twenty minutes. Children in the PAEB-C took part in the PAEB activities five days per week for four weeks. In addition to these activities this group was given daily and weekly Fitbit Challenges.

The Fitbit Challenges came in the form of a log sheet on which students were asked to record their physical activity to meet their weekly fitness challenges. The challenges varied in focus and activity: an individual challenge (steps), a classroom-based challenge (classroom composite steps), a distance based challenge (miles) and a climbing challenge (floors) (see Appendix B). Students were also given a two-digit number by which to identify themselves for testing. These numbers were used to identify students during the pre-and post-tests.

Instruments

d2 Test of Attention. The d2 Test was chosen for three reasons. It measures both visual processing speed and ability to concentrate. It is easy to use and it only takes six to eight minutes to administer. Prior to the beginning of this study, teachers were consulted about what they would like to see tested. These were the factors that were noted as being important to teachers: (1) minimize the amount of time spent on testing and (2) show gains in attention and concentration. The process of administering and reading the directions of the d2 Test was practiced in a pilot study, which determined that the average time of administration was approximately six minutes. The d2 Test is meant to assess the child’s capacity to focus on one stimulus, while ignoring or suppressing others (Brickenkamp & Zillmer, 1998). Distractors come in two forms, dashes above or below the described number (2), and the letter “p” which are was chosen based upon it’s similarity to the letter “d”. The d2 Test of Attention has been shown to be a valid measure of scanning accuracy, speed as well as discriminant validity and fluctuation across trials (Bates & Lemay, 2004; Davis & Zilllmer, 1998).

..   .
d   d   d
      ..   .

Fitbits. Fitbit Charge Heart Rate monitors (Fitbits) were given to both classes in the intervention school. Fitbits are devices that use a non-invasive wireless sensor on the wrist to measure heart rate. The Fitbit relies on an accelerometer to measure these parameters: steps and distance traveled. This study used average daily steps in the final analysis. The Fitbits also measure sedentary, lightly active, fairly active, and very active minutes. The Fitbits are user friendly and have been shown to be both reliable and valid for step count and activity minutes (Kooiman et al., 2015) and energy expenditure (Lee, Kim, & Welk, 2014). Before the students were given the Fitbits the students read instructions regarding the care and maintenance of the device (see Appendix A). Students were taught to put their Fitbits on the charger on Fridays. Students were also told they could charge the Fitbits at the stations, for one hour if the battery was low. Children were then taught about each aspect of the Fitbits: how to determine how many steps they had taken, how far they had gone, the number of calories they burned, and the heart rate as well as the number of floors they had climbed. Children were told that they should try to wear the Fitbits Monday through Friday at all times, except when showering or in the likelihood of getting really wet. Children were also told that they would not get in trouble if they took them off, but they were encouraged to wear them as often as possible.

Once the Fitbits were on and adjusted, the children were told about the timer function and the fact that the Fitbits would buzz if they made it to 10,000 steps. Students in the PAEB-C group were then given sheets to take home that allowed them to record their daily activities (Fitbit Challenge), as well as inform them of each week's challenges throughout the four weeks. Both teachers were encouraged to talk about the Fitbits and to share weekly reports with the kids: however, only the PAEB-C teacher reported that she had done this through the study. They were also both given a Fitbit to wear if they wanted to model the behavior, but only the PAEB-C teacher chose to wear it. The physical education teacher in the intervention school was also sent the printouts of their weekly averages. During physical education she was encouraged to get the kids to think about taking their daily recommended number of steps.

Fitness Assessment. Physical education teachers from both schools provided the study team with the results from an aerobic fitness assessment. The comparison school Pre-and post-tested the mile during weeks 2 and 7 of the study. The intervention school pre-and post-tested the PACER tests during weeks 2 and 7. Both tests are distance-based aerobic fitness tests, which were used to calculate Health-Related Fitness Zones (HRFZ). This is a measurement that is used to provide an estimate of aerobic capacity (Fitness Gram, 2015). The two fitness assessments were something the teachers in each school already used for report cards for students in the fifth grade. Therefore all of the students in both schools took part in the fitness assessments. However, the data were not included in this study for students whose families did not give consent. The data obtained with these measures was used to categorize students into health-related fitness zones: High Fitness (HF), Healthy Fitness Zone (HFZ), and needs improvement (Low Fit [LF]) (Cooper Institute, 2015).

Data Retrieval

On each Friday during the four weeks of the intervention, students were asked to place their Fitbits on the charger before they left for home on the weekend. After students had left the school, the researcher went to the school and uploaded the information from the Fitbits onto a secure Fitbit Software database, Fitabase (Small Steps Lab, 2015). This is a password-protected site, which is accessible only by the researchers and the data management team from Fitabase. The researcher recorded which Fitbits had been placed on the charging station and which Fitbits were missing. The teachers were encouraged to remind students to bring the Fitbits in on Fridays so that the data could be recorded. Teachers were also given printouts of the classroom's average number of steps and minutes, as well as the classrooms total number of steps and distance traveled. Fitbits were collected after students had spent twenty0 days in the schools wearing them. The testing was done the following week. The final fitness assessments were performed by the students during their regular scheduled physical education classes with their physical education teachers during the first week of December.

Data Analysis

Fitness Assessment. A significant level of alpha = .05 was set for all statistical methods. Dichotomous variables were created for minority status (0 = not minority, 1 = minority) and gender (0 = female, 1 = male). Based upon the fitness assessments, students were placed in one of three categories: High Fitness (HF), Healthy Fitness Zone (HFZ), and needs improvement

(LF) (Cooper Institute, 2015). To analyze the HRFZ, a repeated measure MANOVA was used to analyze if differences existed from pre-to post-test in fitness levels by the three study conditions (Comparison, Fitbit-O and PAEB-C) while controlling for gender and race.

Fitbit Data. The data collected from the Fitbits was translated by the Fitabase software into composite measures of sedentary, light activity (LMPA), fairly active (MPA) or very active (MVPA) activity minutes and steps. These were determined based upon Metabolic Equivalents (METs). METS are organized by the World Health Organization (WHO, 2015) into working versus resting metabolic rates. 1 MET is equivalent to sitting (sedentary), 1-3 METs are considered light activity, 3-6 METs is fairly active, and greater than 6 METs is considered very active. Frequency tables, with means and standard deviations were created to determine the differences in physical activity between the PAEB-C and the Fitbit-O groups. Daily data from the Fitbits was excluded from analysis if the student took fewer than 1000 steps or if they had fewer than 840 minutes of wearing the Fitbit. This resulted in losing an average of one day per person during the four week study, or an average of 3.97 (+/-4.83) steps and .72 (+/-1.19) minutes for the Fitbit-O group and 1.87 (+/- 2.21) steps and .90 (+/- 1.56) minutes for the PAEB-C group. Neither group lost individual students (N = 60). Daytime sedentary minutes were calculated by subtracting the age based average of 9 of sleep per night (WebMD, 2016). Therefore, 540 sedentary minutes were subtracted before sedentary averages were calculated. An individual variable, the ratio of fairly and very active minutes/total activity minutes, was created (vafa_av). T-tests were analyzed to see if differences existed between the Fitbit groups controlling for gender and race. Additionally, an interaction effect was run to see if gender and race moderated physical activity levels. Correlations were calculated between student's HRFZ and the number of steps they took during the four week intervention.

d2 Test of Attention. The data analysis for the d2 Test was based upon the guidelines set forth by Brickenkamp and Zillmer (1998). The total number of items processed (TN), the total number of responses minus the total number of errors (TNE), the number of errors divided by TN is the error percent (EP), the Concentration Performance (CP), and the Fluctuation Rate (FR) are calculated and used as a parameter for sustained attention and concentration. The TN number is a measure of working or processing speed and the TNE is a measure of attentional and inhibitory control, or speed and accuracy. The number of errors related to the number of responses (CP) is a measure of sustained attention, concentration, and precision. This (CP) is thought to be a highly reliable measure of overall accuracy of the child's performance. FR is a qualitative variable of within testing fluctuation of attention span and ability to concentrate (Brickenkamp & Zillmer, 1998). A correlation affect was analyzed between a childrens' pre-test of HRFZ and their pre-test for the d2 Test of Attention (Hypothesis 3). This was not completed at the post-test since the d2 test was impacted by Study 1.

Results

Hypothesis 1: Physical activity levels will be higher for students in the PAEB-C group than the Fitbit-O group. The results of the omnibus MANOVA revealed an overall difference among the two groups ($F = 2.199$, $p = .050$) with regards to the mean vector of all Fitbit variables (average daily steps, total steps, very active, fairly active, light activity minutes, and sedentary minutes) when controlling for gender and race. A test of the mean averages for the two groups further revealed that the students in the PAEB-C group took on average 2206 more steps per day than the Fitbit-O group ($F = 3.545$, $p = .020$) (see Table 4.1). The ANOVA analysis of activity by Fitbit groups revealed significant differences in very active minutes ($F = 3.937$, $p = .013$) and in fairly active minutes between the two groups ($F = 6.319$, $p = .001$). Children in the

Fitbit-O group were very active or fairly active for approximately 15 minutes each day (1.3%), while children in the PAEB-C group were very active or fairly active for about 31 minutes (2.9%). The Fitbit-O group spent on average 107 more minutes per day being sedentary (F=4.649, p = .035) but this effect disappeared when controlling for race and gender (F = 1.835, p = .151).

Table 4.1 Mean Number of Steps and Activity Minutes taken by Intervention Group controlling for race and gender

Groups	All categories are based on daily averages.					Percentage
	Number of Steps *	Very Active Minutes *	Fairly Active Minutes *	Light Activity Minutes	Sedentary Activity Minutes	Very and Fairly Active Minutes by Total Activity Minutes*
Fitbit Only	8945.54 (+/- 2518.59)	4.09 (+/- 5.00)	11.28 (+/- 8.00)	230.57 (+/- 82.23)	454.34 (+/- 203.23)	1.3 (+/- 1)
PAEB-C	11151.78 (+/-3421.68)	7.96 (+/- 7.32)	22.98 (+/-17.75)	247.7757 (+/- 76.33)	347.75 (+/- 179.51)	2.9 (+/- 2.3)

*Significance of p<.05

Boys, regardless of intervention type were significantly more likely to participate in very active minutes (F = 6.383, p = .014) and fairly active minutes (F = 7.408, p = .009). However, because an interactive effect between group and gender was suspected, a second ANOVA controlling for race revealed that gender acted as a moderator when both gender and groups were in the model. Both boys and girls in the PAEB-C group took more steps than the Fitbit-O girls (1578 steps) (F = 2.858, p = .032) (see Table 4.2). They also had higher very active (F – 3.12, p = .032) and fairly active minutes (F=4.962, p = .002). Sedentary minutes trended towards significance (F = 2.498, p = .053), with the PAEB-C group getting fewer sedentary minutes than the Fitbit-O group.

A histogram revealed no significant outliers in any of the variables. It did reveal a left skewed distribution with 80% of the children getting less than 11 minutes of very active minutes and 80% getting less than 26 fairly active minutes. The confidence intervals suggested that many of the children are getting far fewer minutes than the daily recommendations, especially for fairly active and very active minutes. No significant differences were found by minority status.

Table 4.2 Mean Number of Steps and Activity Minutes controlling for Race by Groups and Gender

Groups	Gender	Average				
		Daily Steps (p = .008)	Very Active Minutes (p = .005)	Fairly Active Minutes (p = .001)	Light Active Minutes (p = .623)	Sedentary Minutes (p = .05)
Fitbit-O	Girls	8814.95 (+/- 2839.23)	3.36 (+/- 4.54)	9.67 (+/- 6.33)	220.66 (+/- 94.92)	491.43 (+/- 214.01)
	Boys	9193.64 (+/- 1872.93)	5.47 (+/- 5.77)	14.35 (+/- 10.16)	249.41 (+/- 49.17)	380.64 (+/- 167.19)
PAEB-C	Girls	10270.55 (+/- 2460.06)	5.61 (+/- 6.84)	17.22 (+/- 10.90)	267.84 (+/- 75.10)	318.30 (+/-164.90)
	Boys	12221.84 (+/- 4161.87)	10.83 (+/- 7.05)	29.97 (+/- 22.0)	223.42 (+/- 73.07)	385.78 (+/- 195.47)

Hypothesis 2: From pre-to post-test Fitbit-O and PAEB-C groups will show greater increases in cardiovascular fitness compared to the comparison school. T test revealed no significant differences at the pretest between the Fitbit-O and the PAEB-C results for HRFZ (F = .000, p = .993). However the comparison school scored significantly higher than both Fitbit groups on the fitness assessments at pre-test (F 22.79, p=.021). There was no differences in HRFZ results by minority status (F=.03, p=.960). There were significant differences between the fitness assessments by gender. Boys were significantly more likely to be fit (F=21.16, p=.029)

than the girls. Therefore, gender was held constant in the final model to determine if results remained significant.

Frequencies were calculated to determine how many students were in each of the HRFZ: 1= Low Fitness (LF), 2= Healthy Fitness Zone (HRZ) and 3= High Fitness (HF) by pre-and post-fitness tests. A composite of HFZ and HF was calculated to find percentages of students who were at or above healthy fitness zones. Results indicate that only 26% of the PAEB-C and Fitbit-O students fell into the Healthy Fitness and High Fitness zones at the pre-test, while 39% of kids in the comparison groups fell into these zones. The percentage was improved after the four week interventions at the post- fitness to 61% for the PAEB-C group and 56% for the Fitbit-O group. Conversely the percentages decreased for the comparison group falling to 26%. When HRFZ pre-test averages were computed, the results indicated that group fitness levels were significantly lower for both Fitbit groups at the pre-test. The Fitbit groups averaged 1.26, while the comparison group averaged 1.52 (see Table 4.3). Both of the Fitbit groups showed improvements following the four-week intervention. The PAEB-C's HRFZ increased to 1.61, and the Fitbit-O increased to 1.56, whereas the comparison group saw a decrease to 1.32.

Table 4.3 Pre-and Post- Health-Related Fitness Zone's Averages by Study Group

	Means	
	HRFZ pre-test	HRFZ post-test
PAEB-C	1.26 (+/-.45)	1.61 (+/- .50)
Fitbit Only	1.26 (+/-.45)	1.56 (+/- .51)
Comparison	1.52 (+/-.71)	1.38 (+/- .71)

While controlling for race and gender, a repeated measure MANOVA revealed that there were significant differences in the change over time for HRFZ (F = 10.302, p=.002) and by group (F = 19.841, p = .000), by gender (F = 5.763, p = .018), and by minority status (F = 9.843, p = .002). Children in the Fitbit-O and PAEB-C groups increased their fitness, while the comparison group saw a slight decrease over time (see Figure 4.1). The effect was also significant for gender (p = .003) and minority status (p = .004) so a repeated measure ANOVA also was analyzed to assess the interaction. No interactive effect was found between gender and group, but the effect between race and group was significant (F= 8.713, p = .001).

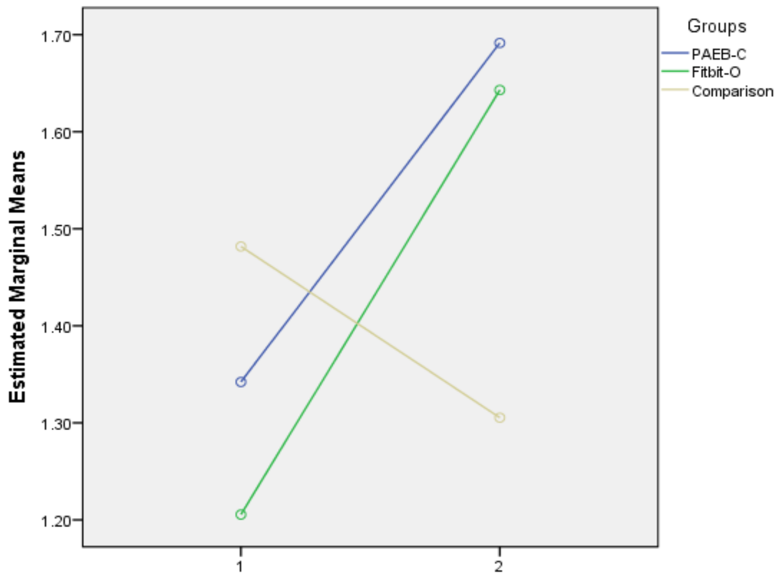

Figure 4.1 Pre-to Post-test Means for Health-Related Fitness Zones

Both girls (see Figure 4.2) and boys (see Figure 4.3) showed improvements in the Fitbit Groups, but not in the comparison group. Boys showed the greatest overall improvement from pre-to post assessment (p=.003). All children regardless of minority status, exhibited improvements in HRFZ in the Fitbit groups compared to the comparison school (p = .001). However, upon closer inspection, non-minority students (see Figure 4.4) improved in both the Fitbit-O and PAEB-C groups (p = .001), while minority students (see Figure 4.5) displayed improvements in fitness only in the PAEB-C groups (p = .003).

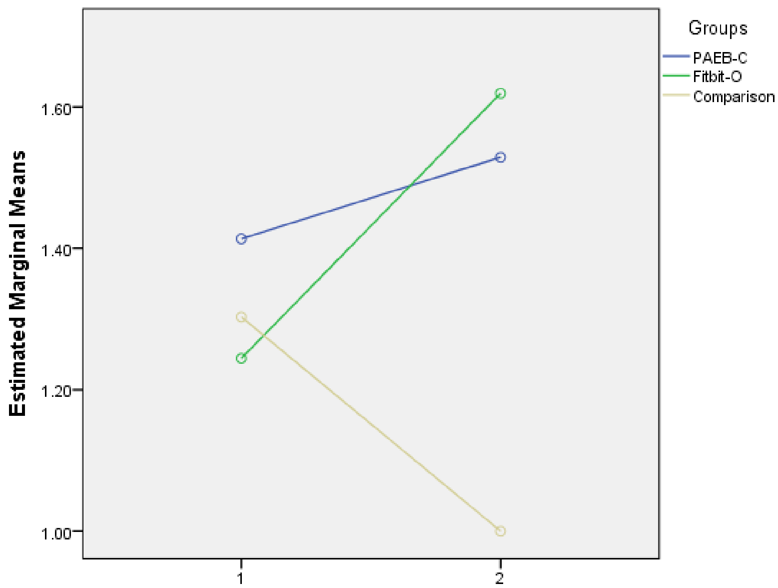

Figure 4.2 Pre-to Post-test of Means of HRFZ in Girls

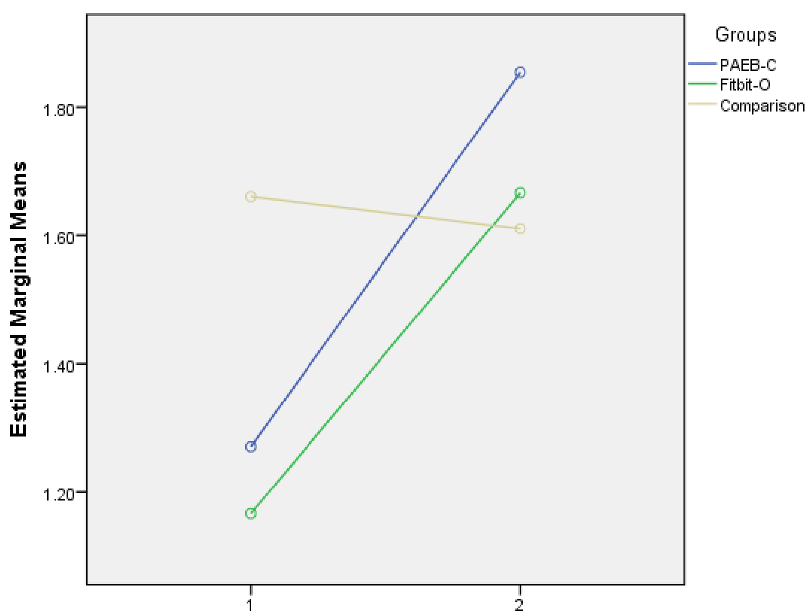

Figure 4.3 Pre-to Post-test Means for HRFZ in Boys

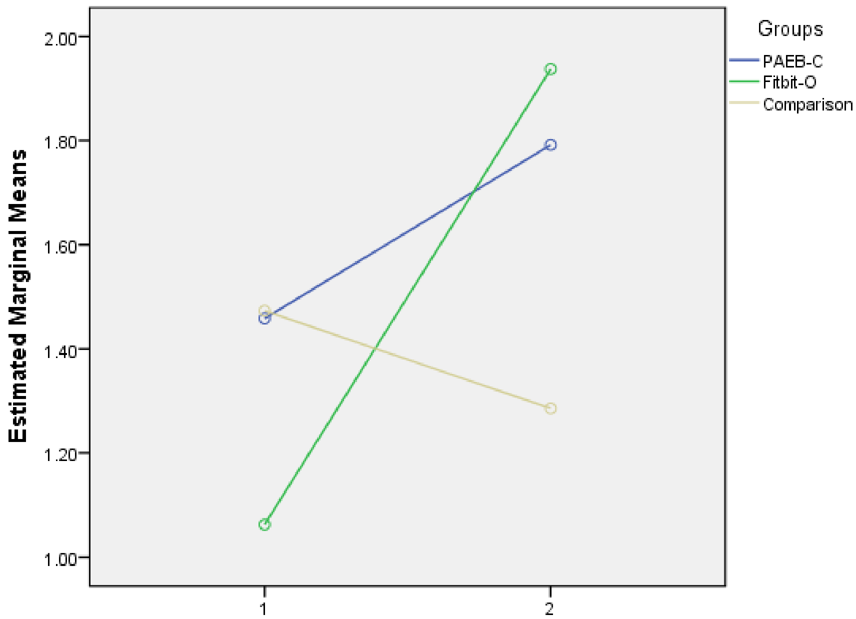

Figure 4.4 Pre-to Post-test Means in HRFZ for White Children

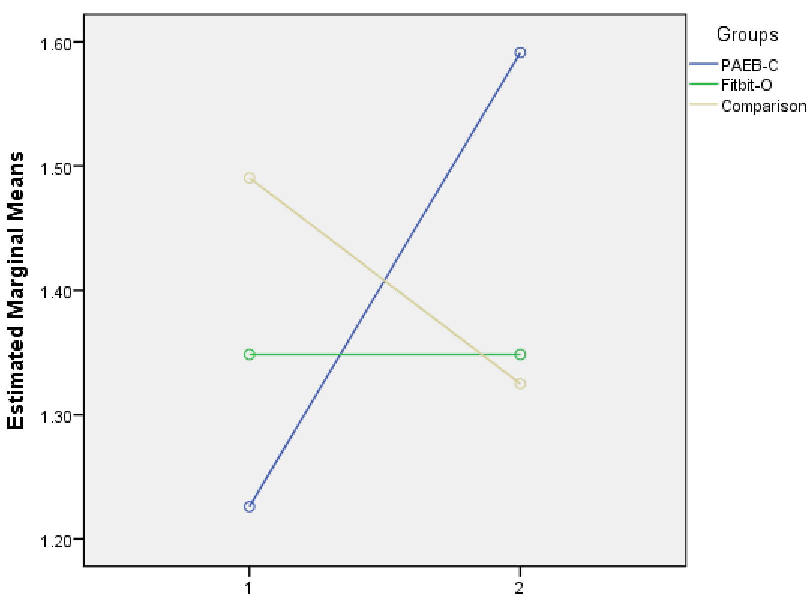

Figure 4.5 Pre-to Post-test Means for HRFZ in Minority Children

Post hoc analyses of the pre-to post- HRFZ revealed significant differences between both the Fitbit-O (F = 25.007, p = .000) and PAEB-C (F = 29.327, p = .000) groups and the comparison group, but no differences between the two Fitbit groups. The children in the PAEB-C group did see greater increases, but this was not significant. However, minority children in the PAEB-C groups experienced significantly greater improvements in fitness than in the Fitbit-O intervention (F = 10.138, p = 003). No significant relationship was found between fitness and gender when comparing the different groups (F = 2.463, p = .121). However, boys in the PAEB-C group saw significant changes on their HRFZ fitness tests (F = 8.649, p = .004) when compared to the other two groups. Since the efforts of the intervention were to increase steps and not specifically cardiovascular exercise, it is not surprising to find that no significant differences in fitness were found between the two intervention groups.

Hypothesis 3: At baseline, children in the Healthy Fitness Zone (HFZ) and the High Fit Zone (HF) will do better on the d2 Test than those who are below the recommended Health-Related Fitness Zones (HRFZ). Analysis of variance revealed differences in the d2 variables among the three HRFZ groups at pre-test, but not at post-test. Students who were classified as healthy or high fitness zone (at the pre-test) were significantly more likely to do better on the d2 test for TN, TNE, CP, and FR (Table 4.4). Furthermore, the results of post hoc comparisons revealed significant differences in the d2 Test of Attention between each of the 3 fitness groups. Mean differences in EP (t = 8.196, p = .041), CP (t = 2.052, p = .043), and FR (t = 2.924, p = .004) were found between the Low Fit and the Healthy Fitness Zones (see Table 4.5). Differences were also found between the Low Fit and High Fit Zones for TN (t = 3.841, p = .000), TNE (t = 3.641, p = .001), and CP (t =2.314, p=.023) (see Table 4.6). Finally, significant differences were found between the Healthy Fit and High Fit groups for TN (t = 3.293, p = .002) and TNE (t = 2.579, p = .014) (see Table 4.7). A correlation of r = .230 was found between students' post- HRFZ and their very active minutes (p = .04). But, no significant correlations emerged between the Fitbit activity minutes/steps and the post- d2 Test of Attention.

Table 4.4 Means Scores on the pre- d2 tests by Health-Related Fitness Zone

Pre-test	TN	TNE	EP	CP	FR
Low Fit	289.79 (+/- 55.04)	265.32 (+/- 52.17)	8.43 (+/-9.68)	98.28 (+/-30.28)	16.71 (+/-7.51)
Healthy Fitness Zone	292.87 (+/-56.93)	279.40 (+/-56.33)	4.55 (+/-5.32)	111.27 (+/-26.62)	12.43 (+/-4.37)
High Fit	375.57 (+/- 72.28)	341.86 (+/-63.92)	7.99 (+/-12.05)	127.14 (+/-44.41)	13.71 (+/- 5.50)

Table 4.5 T-test for Equality of Means between Low Fit and Healthy Fitness Classifications

	Pre-test of HRFZ	Mean	Standard Deviation
TN (p = .798)	Low Fit	289.79	55.04
	Healthy Fitness	292.87	56.93
TNE (p = .225)	Low Fit	265.32	52.22
	Healthy Fitness	279.40	56.33
EP (p = .041)	Low Fit	8.43	9.69
	Healthy Fitness	4.55	5.32
CP (p = .043)	Low Fit	98.28	30.281
	Healthy Fitness	111.27	26.617
FR (p=.004)	Low Fit	16.71	7.513
	Healthy Fitness	12.43	4.368

Table 4.6 T-test for Equality of Means between Low Fit and High Fitness Classifications

	Pre-test of HRFZ	Mean	Standard Deviation
TN (p=.000)	Low Fit	289.79	55.040
	High Fit	375.57	72.284
TNE (p=.000)	Low Fit	265.32	52.217
	High Fit	341.86	63.920
EP (p=.909)	Low Fit	8.43	9.69
	High Fit	7.99	12.05
CP (p=.023)	Low Fit	98.28	30.28
	High Fit	127.14	44.41
FR (p=.307)	Low Fit	16.71	7.51
	High Fit	13.71	5.50

Table 4.7 T-test for Equality of Means between the Healthy Fit and High Fitness Classifications

	Pre-test for HRFZ	Mean	Std. Deviation
TN (p=.002)	Healthy Fitness	292.87	56.926
	High Fit	375.57	72.284
TNE (p=.014)	Healthy Fitness	279.40	56.329
	High Fit	341.86	63.920
EP (p=.247)	Healthy Fitness	4.55	5.32
	High Fit	7.99	12.05
CP (p=.222)	Healthy Fitness	111.27	26.62
	High Fit	127.14	44.41
FR (p=.510)	Healthy Fitness	12.43	4.368
	High Fit	13.71	5.499

Discussion

Physical inactivity is one of the biggest public health concerns in America (Blair, 2009). Each year, approximately 3.2 million deaths worldwide are directly related to physical inactivity and subsequent reductions in cardiovascular fitness. This makes physical inactivity a leading risk factor for global mortality (WHO, 2015b). Much of this inactivity may be the result of sedentary behaviors during the school day. Children spend a large percentage of their time in schools being sedentary. Therefore, introducing more physical activity to a child's school day may be beneficial in helping children to meet daily physical activity guidelines of 60 minutes and improve cardiovascular fitness (McNeely & Blanchard, 2015; WHO, 2015). This study compared the effects of two intervention strategies, the Fitbit-O and PAEB-C groups as a way to increase physical activity levels and Health-Related Fitness Zones (HRFZ). It also examined whether a relationship existed between fitness scores and physical activity and the d2 Test of Attention.

Hypothesis 1: Physical activity levels will be higher for students in the PAEB-C group than the Fitbit-O group. The PAEB-C group participated in 2206 more average steps/day, and were more likely to participate in very and fairly active minutes than the Fitbit-O group. One review article by Dobbins, Husson, DeCorby and LaRocca (2013) reported evidence that school-based physical activity interventions were likely to improve MVPA levels by as little as five and up to forty-five minutes. Similarly, other studies that have added physical activities specifically to classrooms have also seen improved physical activity levels (Fedewa et al., 2015; Ma et al., 2015; Van der Niet et al., 2014). However, our intervention requires far less energy on the part of the teachers and staff to run. In their review, Babey, Wu, and Cohen (2014) emphasize the importance of adding the breaks to the classroom. Short activity breaks are a feasible and cost-effective way to increase physical activity in schools.

In addition to an increase in physical activity levels, the students in the PAEB-C group were less likely to be sedentary. In fact, being in PAEB-C group meant that on average students took around the recommended daily number of steps 11152 (+/- 3421), which was not the case for the Fitbit-O group (8946 +/- 2519). Although 10,000 steps is the most commonly recommended number of steps, the authors of a Canadian study suggest that students should take upwards of 12,000 steps to maintain healthy physical activity levels (Early Movement Academy, 2012). Although students in the PAEB-C were successful at achieving 10,000 steps on average, the study may want to aim for more steps in the future on the Challenge activity sheets. It is important, however, to note that the PAEB activities alone could not account for all of the step differences. In a preliminary trial of the PAEB videos (Harris & Chen, in preparation), eight 4th through 6th grade children took an average of 250 steps while performing the coordinated bilateral activities. Additionally, since the PAEB activities are mostly fine and small gross motor skills, they predominantly fell into the light activity category. This suggests that the PAEB were more likely responsible for some of the differences in reducing sedentary minutes in the PAEB-C group. The PAEB-C group had 107 fewer sedentary minutes/day than the Fitbit-O groups. Therefore, the Challenge may have also played an important part of increasing steps; something about taking part in the PAEB or the Challenges triggered students to be a bit more active than the Fitbit-O group.

The results of the study also indicate that both experimental groups were likely more physically active than the comparison group. This would be consistent with hypothesis 2, which states that Fitbit-O and PAEB-C groups will show greater increases in Health-Related Fitness Zones (HRFZ) from pre-to post-tests compared to the comparison school. In order to improve aerobic fitness, students needed to take part in more physical activity, particularly moderate to vigorous physical activity. Both Fitbit classes saw an increase in fitness zones, therefore it is likely they also were more active. However, since part of the study was to examine if just having the Fitbits improved students fitness, there were no steps or activity minutes collected for the comparison school. A recommendation for future studies may be to have a basic pedometer to record how much more efficacious the Fitbit itself is over another data collection tool.

The significant reduction in sedentary minutes for the PAEB-C group compared to the Fitbit-O group is also worthy of note. MVPA levels are not the only problem areas for children. Instead, most children are spending more time being sedentary, averaging 7 ½ hours a day (Rideout et al., 2010). The Fitbit-O group averaged just over 7.6 hours, while the PAEB-C group spent an average of 5.8 hours. This is a significant difference between the intervention strategies, and it may be a feasible way to reduce sedentary time in the schools. Children spend a disproportionate time in a school environment that is mostly sedentary (McNeely, & Blanchard, 2015). Efforts that are easy to use and very feasible can help to get children up and active in school. This is seen in other studies that have focused on adding short duration activities directly into the classroom (Budde et al., 2008; Fedewa et al., 2015; Ma et al., 2015; Van der Niet et al., 2014). This could have a significant impact on a child’s overall health as well as cognitive functioning, and is supported by evidence that suggests increased sedentary behaviors hinder neuroelectric functions of the brain which further supports cognitive integrity, attention, and information processing (Chaddock et al., 2011). This is further supported by baseline data in this study which showed that a student’s fitness was directly correlated to the pre- d2 Tests of Attention (Hypothesis 3).

It is important to note that in addition to the average steps overall, activity minutes increased for students in the PAEB-C group as well. On average, PAEB-C students spent 7.96 (+/- 7.32) minutes in very high activity, while the Fitbit-O group spend 4.09 (+/- 5.00). This difference of 50% accounts for the significance, however, the confidence intervals highlight that many of the students are not getting any very active minutes. This corresponds with the results, which showed very few children falling into the high fitness zone (6.2%). This is further supported since very high and fairly high activity minutes were directly correlated to HRFZ High Fit zones ($p=.04$). These high fit zones require a much higher level of aerobic cardiovascular fitness. Since fitness is directly associated with moderate to vigorous physical activity it is reasonable that the ability to carry out and sustain physical activities without fatigue would be related to time spent in this study doing MVPA (Caspersen, Powell, & Christenson, 1985). Since so few children are taking part in very high activity minutes in this study, it continues to explain why there are still so few children who fall into the high fit zone. Still, the WHO, in a review article (Langford et al., 2014), reported that although intervention effects may be small for interventions that are attempting to improve physical activity and fitness, even this small impact may be enough to improve the public's overall health.

The 2008 Physical Activity Guidelines for Americans recommend that school-aged children participate in 60 minutes or more of moderate-to-vigorous physical activity (MVPA) daily (Department of Health and Human Services [DHHS], 2008). In this study, the Fitbit-O group averaged 246 (+/- 95) minutes of total activity/day during the four weeks of the intervention, while the PAEB-C group averaged 279 (+/- 101). This is higher than reported norms from the National Association for Sport and Physical Education (NASPE), where only 1 in 3 children are meeting their activity levels each day (NASPE, 1999). However, very few of the minutes in this study were spent in MVPA, ranging from 15.47 (+/- 13) in the Fitbit-O group to 30.94 (+/- 25.07) in the PAEB-C. Instead, most consisted of light activity minutes. This is consistent with the findings in Van der Niet et al., (2014) who found that most of the time spent in physical activity consisted of light physical activity.

Though it appears the PAEB-C group got more very and fairly high activity minutes than the Fitbit-O group, most of these differences can be attributed to time spent in activity by boys. The differences between the groups was eliminated when gender was factored into the equation for fairly, very, and light activity minutes but not for sedentary minutes. On average girls spent 18 (+/- 15.2) minutes, while boys spent 33 (+/- 26.8) minutes in moderate to vigorous activity (MVPA). Since the Physical Activity Guidelines (DHHS, 2008) calls for 60 minutes or more of MVPA, these numbers are very low. This is especially true for girls who spent only a fraction of their time in moderate to vigorous physical activity. However, it continues to match up with similar data found for girls and boys with regards to MVPA. Ridgers, Salmon, Parrish, Stanley and Okely (2012) found the type of activity, particularly MVPA, was much more common in boys than girls. But this is not only a problem for girls. When the confidence intervals are taken into consideration, it is clear that many kids spent little to no time in MVPA. This may also explain the low numbers of children who fell into the High Fit category of the HRFZ.

Hypothesis 2: From pre-to post-test, Fitbit-O and PAEB-C groups will show greater increases in cardiovascular fitness compared to the comparison school. The results confirm this expectation. At baseline, the students in the two experimental groups had slightly below U.S. average fitness scores. Only 26% of students met the healthy fitness standards in the Fitbit School, while in the comparison school 39% of the students were in this category. National results suggest that one in three students normally fall into this category (Pate et al., 2006). After the four-week interventions, these results changed significantly. 61% of the PAEB-C and 56% of the Fitbit-O students were assessed to be in the HF and HFZ. Meanwhile, the percentages dropped to below average for the comparison school (26%). It is important to note that these increases occurred during a time when seasonal changes sometimes act to reduced fitness

(Mendez, 2016); this was observed in the comparison group. This result is similar to Fedewa et al.'s (2015) results indicating that adding daily physical activity to the classroom was influential in reducing the seasonal step decreases found during winter. Though they looked at physical activity and not fitness, this study saw a similar result with increased fitness levels in the intervention groups while declines were seen in the comparison group. This increase demonstrates the efficacy of introducing Fitbits in the classroom and contributes evidence to support minimal contact interventions in schools. It gives evidence that adding just a Fitbit for all students can improve aerobic fitness. It supports easy-to-use technology to improve children's fitness without having to invest significant time into preparing lessons or specific physical activities during the school day.

Although there were no significant differences in HRFZ between the Fitbit-O and the PAEB-C groups, the fitness results did trend in this direction. Therefore, the results do not support the idea that adding the PAEB intervention would further improve aerobic fitness. This was not entirely unexpected since the PAEB activities were not meant to increase aerobic capacity. Instead they were meant to get students to focus and to help facilitate higher coordinated fine motor skills. However, the findings also suggests that there was no added aerobic benefit to the Fitbit Challenges, though there were more steps. Two reasons may account for this. First, the challenge teacher reported that she did not really check on the students' challenge worksheets. Second, the challenge worksheets did not include any challenges that asked students to work out at a moderate to vigorous capacity. This may be something to consider in the future, since the Fitbits do allow for heart rate monitoring and therefore could be used to encourage children to spend a greater amount of time in their target heart rate zones. And with the already added steps taken from adding the Fitbits, and the trend towards higher fitness without significant results, there may be something to adding a Fitbit Challenge. Therefore further studies may benefit from additional aerobic capacity challenges. Another explanation: overall excitement of having a Fitbit for four weeks. Maybe in the long run the challenges are necessary to keep the momentum going.

Though there was no difference in HRFZ for boys and girls at the pre-test, boys increased their HRFZ significantly from pre-to post-test compared to the girls (p=.003, F=9.251). Additionally, boys were more likely to take part in more very and fairly active steps than girls throughout the duration of the study (Table 4.2). Boys were 50% more likely to be doing very active minutes (4.42 versus 8.71) and 45% more likely to be doing fairly active minutes (13.24 versus 23.86) than girls (Graph 2). When gender was added as a covariate the differences in very active and fairly active minutes made the group effect insignificant for fairly and very active minutes. This is consistent with other studies, which showed that gender differences exist between amounts of physical activity seen in schools (Kohl, Fulton, & Caspersen, 2000; Ridgers et al., 2012; Sarkin, McKenzie, & Sallis, 1997). Sarkin et al. (1997) found that boys were more likely to do more physical activity in recess and gym. Still, a few differences were highlighted in our study that would continue to support these intervention strategies for use in schools. Wickel, Eisenmann, and Welk (2009) found that there were no specific differences in MVPA between boys and girls. No differences were present at the start of the study, which suggests that this study was successful at engaging boys into participating in more MVPA as a result of the intervention. Meanwhile in a review article, Kohl et al. (2000) suggested that more effort should be spent on finding ways to promote physical activity for girls. Though significant differences did not exist from pre-to post-test for girls, girls in both Fitbit groups experienced increases in their fitness levels.

Significant intervention effects were found by race as well for HRFZ. At the outset of the study, there were no differences in HRFZ by race; however, the HRFZ pre-test to post-test changes showed that race status was significantly related to change (Figure 4 and 5). Although both groups showed improvements, only children who identified as being white were significantly more likely to show significant changes in HRFZ from pre-test to post-test when comparing the three groups by minority status (p=.001, F=11.991). This is consistent with data from a study done in 100 U.S. cities, which indicates that both gender and race are significantly linked to compliance with physical activity guidelines (Butcher, Sallis, Mayer, & Woodruff, 2008). In this study boys who also identified as white non-Hispanic were significantly more likely to comply with activity guidelines than girls or minority peers (Butcher et al., 2008). However, when a post hoc analysis was run, minority children were significantly more likely to see improvements in the PAEB-C group.

Hypothesis 3: At baseline, children in the Healthy Fitness Zone (HFZ) and the High Fit Zone (HF) will do better on the d2 Test than those who are below the recommended Health-Related Fitness Zones (HRFZ). Consistent with hypothesis 3, a relationship was found between fitness and executive function at the pre-test. When the pretests for HRFZ were split into the three categories (LF, HFZ, and HFZ), and compared to pre- d2 test results significant differences were found. The d2 variables, TN, TNE and CP significantly increased in association with higher levels of fitness, while FR variables were lower. This supports the concept that students who had higher aerobic fitness were more likely to see higher baseline scores of executive functioning than students who were less fit. But very few studies have looked directly at fitness testing and executive function (Best, 2010; Van der Niet et al., 2014). Buck, Hillman, Castelli (2008) found improvements in cognitive processing and reaction time (measured by the

Stroop test), based upon fitness level. Van der Niet et al. (2014) found that inhibition, working memory, cognitive flexibility, and planning was directly related to fitness levels (Van der Niet et al., 2014). Since the relationship between fitness and executive function seems to be important, this should be considered if changes are made in the future to this intervention. This study was not focused specifically on improving HRFZ, but instead on increasing step count. Therefore, adding challenges to monitor heart rate or high activity minutes may prove to be beneficial in efforts to establish whether or not a direct relationship exists between HRFZ and fitness. A study that also focuses on maintaining that fitness over a longer period of time should be considered.

Consistent with the results by Hillman's series of studies (2005; 2009), the differences found in the pre-test were pronounced even when groups were compared in post hoc tests. Children who were classified in the HFZ by their fitness test did better in EP, CP, and FR rate than children in the low fit classification. This was true also when those who were classified as "high fit" were compared to the low fit groups for TN, TNE and CP. Finally, differences were found between the HFZ and HF groups, where increased fitness meant a significant improvement in TN and TNE. Barenberger, Berse, and Dutke (2011) suggest that this is what we should expect to see. Their review indicates that physical activity over the short and long term improves executive functioning. However, in this review (Barenberger et al., 2011) none of the studies examine fitness levels specifically. This study looks at each level of fitness and shows that there may be more specific relationship improvements by fitness level and executive function. Voss et al. (2011) found that this was the case for activation of cognitive control in brain networks of preadolescent children; aerobic capacity was directly correlated to increases in cognitive performance. Similarly, in this study, TN and TNE was higher in the high fit group than both of the less fit groups. Since TN measures processing speed and TNE speed and accuracy and both are related to cognitive performance, this further supports the findings by Voss et al. (2011), which suggest that fitness is related to cognitive performance. Additionally, differences were also evident for CP between the LF and HFZ groups. This implies that the benefits may be more pronounced between high fit students and low fit. This further supports the theory that levels of fitness may directly benefit executive functions. This is important since Van der Niet et al. (2014) found that executive function acted as mediator between fitness and academic achievement. As a result, improvements in executive function that may be gained through invention studies, like this one, can help to facilitate improvements in academic performance.

The relationship between fitness and physical activity and the d2 post-test of attention was not analyzed, though some might think it is important. According to Van der Neit et al. (2014), who found a correlation between all total volume of physical activity and executive function, this may be an important factor. However it was not hypothesized, since the PAEB activities were meant to support changes in executive functioning independent of activity levels. Therefore, any finding could have been impacted by the result of the PAEB-C intervention effect, which showed improvements as a result of coordinated bilateral physical activities (study 1). Best (2010) found similar results, "not all aerobic exercise benefit executive functioning equally" (p.331). In this review, Best (2010) suggests that more cognitively based physical activities (like seen in study 1) may have greater benefit in increasing executive function. In study 1, improvements in the d2 test variables were found to be directly correlated to taking part in the PAEB activities. A future should focus on physical activity levels and fitness levels pre- and post-, to see if changes occur over time.

Limitations

Several limitations should be noted in this study. Selection of the participants may have limited the generalizability of the results of this study. Students in the comparison group were more fit at the outset of the study. This may be in part related to the variations in race and social economic status (SES), measured by free and reduced lunches, found between the Fitbit and comparison schools. Two other schools may have been better suited as control schools since they had more similar race and SES distributions, but both were eliminated due to conflicts with other programs in the district (School District Demographics System, 2014) (see Appendix E). Additionally, the Fitbit Challenge was meant to be distributed to both Fitbit groups, to examine if there was a fitness-related difference between children participating in the Fitbit Challenge and the PAEB intervention. However, the teacher of the Fitbit-O class never handed out the Fitbit Challenge worksheets. This made it difficult to establish the specific intervention effect. Finally, the Fitness assessment data were based upon two different measures, the mile and the PACER tests. Originally, both schools were meant to do the mile, but the Fitbit school underwent construction during the study, which did not allow them to complete a post- assessment of the mile. Therefore, their HRFZ results were based only on the PACER test (also collected by the Fitbit school, while the comparison group used only the mile, since they did not do the PACER test. Both tests, however, were aerobic distance tests and both have are used for the purposes of creating a HRFZ in the Fitness Gram (Cooper Institute, 2015).

Conclusions

The positive findings in this study can help to drive home the importance of adding physical activity to the classroom, as well as the potential benefits of physical activity on overall school performance. The introduction of Fitbits was successful at increasing HRFZ for all children in the intervention groups and the PAEB and Fitbit Challenges together improved physical activity levels. As a result of the intervention strategies, students, particularly boys, were more likely to be physically active when given the Fitbits. This study also showed a direct correlation between executive functioning and the pre-test of HRFZ and no negative correlations at the post-test or for physical activity levels. This intervention demonstrates that even small changes within a classroom-based setting can be effective at getting children to be more active. With only a little extra effort from teachers, administrators and school districts, children were able improve their physical activity and fitness levels while at school.

Chapter 5

Impact of Technology-Enhanced Classroom Physical Activity Intervention on Motivation.

Examining the relationship between a child's motivation, attitudes, physical activity, and aerobic fitness.

Abstract

Engaging children in physical activity is essential for insuring healthy populations who participate in lifelong physical activity. This study looked at whether the introduction of Fitbits alongside an enhanced physical activity intervention increased a child's autonomous self-determined (SDT) motivation and attitudes towards physical activity. This study also examined if relationships exist between a child's motivation, fitness, or physical activity. Three groups, from two schools (N=116) were given pre- and post- fitness and Children's Physical Activity Attitudes and Behavior tests (PAAB). Children in the Fitbit Only (Fitbit-O) and Physical Activities Engaging the Brain (PAEB): six-minutes of daily activities + Fitbit Challenge (C) were given Fitbits, which were used to collect physical activity data. No differences in SDT motivation were found between the two Fitbit Groups, but the Fitbit groups scored significantly higher for intrinsic ($p = .013$), identified ($p = .045$), perceived competence ($p = .006$), perceived control ($p = .013$), and attitude ($p = .002$) than the comparison group. No definitive results were found between physical activity levels and motivation. But there was a significant relationship between a child's post- fitness zone and pre-tests for intrinsic ($p = .000$), perceived competence ($p = .001$), perceived control ($p = .016$), and attitude ($p = .008$). A stepwise regression found that pre-tests for Autonomous Motivation and Attitudes (AMA) and Self Perceptions (SP) were predictive of a child's post fitness zones ($p < .0001$). This study is the first to find a link between SDT motivation and fitness in schools.

Key words: Fitbit, Physical Activity, Self-determined Motivation, Physical Fitness

Introduction

The concept of using technology to promote physical activity through motivation is not new, but over the past few years it has become more personalized. Machines in gyms are now capable of logging personal information and preparing workouts based upon set parameters. Personalized armbands, wristbands, shoes and phones are able to track your steps, heart rate, and calories. This new personalized data are changing the way we think about physical activity. Still, very little is known about the motivational factors that can act to promote physical activity and fitness (Pannekoek, Piek, & Hagger, 2013). However, until now, Fitbits have not been studied in the schools for the purpose of tracking changes in motivation. Therefore, this study will look at whether the introduction of Fitbits alongside an enhanced physical activity intervention can increase a child's autonomous self-determined (SDT) motivation and attitudes towards physical activity. Furthermore, it will examine if a relationship exists between a child's SDT motivation and fitness or between the child's motivation and physical activity levels. In order to gain a better understanding of this relationship, the following paragraphs will used to (1) examine studies that look at the relationship between SDT and physical activity and fitness, (2) examine technologies that have been used to increase motivation and physical activity in schools, and (3) establish the feasibility of using Fitbits in the schools.

Background

Developments in technology have changed the playing field for schools that want to engage students in physical activity. Technologies where the user is made to be both autonomous and immersed in the media abound (Vorderer, Bryant, Pieper, & Webber, 2006). However, few school-based studies have examined technologies that promote fitness while examining attitudes and SDT motivation. (Goldfield, Kalakanis, Ernst, & Epstein, 2000; Mikkola, Kumpulainen, Rahikkala, Pitkanen, Korkeamaki, & Hytonen, 2010; Preuschl, Baca, Novatchkov, Kornfeind, Bichler, & Boecskoer, 2010; Roemmich, Gurgol, & Epstien, 2004).

Motivation, attitudes, physical activities, and fitness. What motivates children to take part in physical activity has not been studied nearly enough (Pannekoek, Piek, & Hagger, 2013). Even less is known about how motivation can be directly linked with physical fitness versus physical activity (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). What is currently known about motivation is that it can be a driving factor in whether or not an individual takes part in physical activities. Teixeira et al. (2012) reviewed 66 studies that examined SDT, exercise, and physical activity. The researchers found consistent positive relationships between autonomous forms of motivation and exercise behavior. They concluded that using SDT was an acceptable way to understand the motivation behind a child's physical activity behavior (Teixeira et al., 2012). They also drew a further conclusion that identified regulation may prove to be the best correlate of exercise (Teixeira et al., 2012). To test this finding Dishman, McIver, Dowda, Saunders, & Pate, (2015) examined autonomous and controlling forms of motivation in middle school students and concluded that both intrinsic and identified regulation were both strongly related to a child's physical activity. Both studies (Dishman et al., 2015; Teixeira et al., 2012) called for longitudinal and experimental studies that examine exercise causality in relationship to specific SDT subcategories. Teixeira et al. (2012) also called for studies that focused on direct feedback and promotion of physical activity through the SDT model.

In a systematic meta-analysis Owen, Smith, Lubans, Ng, & Lonsdale (2014) found that the most common motivators for participating in physical activity were autonomous forms of motivation: intrinsic and identified regulation. Conversely, greater negative associations were identified in controlled forms of motivation and amotivation. An example of this was found in the Seghers, Vissers, Rutten, Decroos, & Boen (2014) study, which looked at a child's leisure activity, measured by step count. This study found that a child's physical activity levels were directly related to intrinsic motivation and a feeling of autonomy in the children who took part in regular physical activity and who were normal weight. In contrast, those who were overweight, and less active reported lower values related to autonomy and higher extrinsic scores (Segher et al., 2014). Since the cross-sectional design ruled out investigating causality, the researchers suggested that a study that gathered pre-and post- data should be completed. Ha and Ng (2014) established that a correlation existed by examining the relationship between autonomous motivation, physical activity, and sedentary behaviors (measured by an Actigraph GT3X), but they did not measure fitness. Children who were more autonomously motivated participated in more MVPA and less sedentary behaviors for the next seven days. Since it appears to be important to engage children through autonomous forms of motivation, using new SDT strategies to get students to pursue physical activity may be a key component in reducing physical activity declines (Ntoumanis, 2001).

SDT counseling and online sources (Young & Active) were used to get students to take control of changing their physical activity levels in a study done by Riiser, Londal, Ommundsen, Smastuen, Misvaer, & Helseth (2014a). The Young & Active program in the Riser et al. study encouraged students to set goals based on SDT theory while also receiving weekly counseling sessions. This study resulted in slight increases in cardiovascular fitness as well as improvements in BMI after counseling. Furthermore, Riiser, Ommundsen, Smastuen, Londal, Misvaer, & Helseth, (2014b) found that SDT acted as a mediator for aerobic fitness and health-related quality of life. This suggests a causal relationship between SDT and fitness, which merits further study. Mayorga-Vega and Viciana (2014) found that children (11-16 years) fell into two categories —moderate and high motivation —measured by an intrinsic framework (to know, accomplish, experience) as well as by identified regulation and introjected. Those who scored higher in these combined categories were more likely to reach the recommended physical activity levels.

Using fitness technologies to improve motivation and attitudes. There have been no studies so far that have examined how Fitbits could be used to improve attitudes and motivation for children in schools and in turn impact physical activity and fitness. Therefore, this section focuses on studies that have introduced other technologies into classrooms as a way to increase a child's motivation to be physically active. The most common technologies studied alongside attitude and motivation have been fitness-based technologies or Exergames (Lanningham-Foster, Foster, McCrady, Jensen, Mitre, & Levine, 2009). The strategy of using exergames has been very successful at increasing children's intrinsic motivation and improving attitudes towards physical activity (Finco, Reategui, Variani, & Zaro, 2013; Gao, Podlog, & Huang, 2013a; Gao, Zhang, & Stodden, 2013b; Saelens & Epstein, 1998; Sun, 2013). Gao et al. (2013a) found significant increases in intrinsic motivation when children took part in Dance, Dance Revolution (DDR). In a related study (Gao et al., 2013b), the children took more steps during dance, but they reported liking the DDR more. Finco et al. (2013) also found improvements in social engagement with peers lead to increased physical activity. Since relatedness, or seeking to secure and make connected relationships, is a part of the SDT model, Finco et al's study supported a broader association to the SDT. Sun (2013) found that students continued to be motivated by Exergaming stations for two semesters (18 weeks), whereby motivation levels dropped, and even after this time physical activity levels remained higher.

The idea that technology can directly impact whether or not a child might report enjoying or taking part in an activity is an important one. Since children are more likely to continue to be physically active if they are motivated by the activity (Owen et al., 2014; Seghers et al., 2014; Teixeira et al, 2012), how much they are motivated by using the technology may also play an important role. Futurestep (Mikkola et al., 2010), a study using Polar heart rate monitors, examined how students' awareness of their own fitness could be used to improve motivation. The introduction of the Polar devices increased the students' awareness of their own physical activity and acted as a way to increase that physical activity as well as improve motivation (Mikkola et al., 2010). Preuschl, Baca, Novatchkov, Kornfeind, Bichler, and Boecskoer (2010) found that using a Mobile Motion Advisor with high school students created a feedback loop that increased students' positive attitudes towards being more physically active. Horne, Hardman, Lowe and Rowlands (2009) did not look at how physical activity impacted motivation, but instead reversed the two previous approaches and used motivational strategies to get students to be more active. Children followed internet fictional models and received rewards when they increased their pedometer steps/day from baseline by 1500 (Horne et al., 2009). This goal-oriented motivational model found significant improvements in physical activity in children 9-11 years old (Horne et al., 2009).

Not only do students want to take part in the fitness games, the students may even choose to do more physical activity as a way to earn technology time (Goldfield et al., 2006; Saelens et al., 1998, Roemmich et al., 2004). Two studies (Goldfield et al., 2006; Roemmich et al., 2004) took different approaches while using accelerometers with open feedback. They offered children aged 8-12 years (Goldfield et al., 2006) and overweight and obese children (Roemmich, 2004) of the same age one hour of additional time on electronics (television/VCR/DVD) for every additional 400 counts of physical activity the students got. As a result, children in the open feedback schools participated in more MVPA and less sedentary time. Though the motivation seems to be evident, it was not measured in these studies. De Cocker, De Bourdeaudhij, and Cardon (2008) found similar results using online feedback in a random sample of individuals (18 to 75 years). The participants significantly increased their walking and MVPA in all the groups, but they also found that those who received educational materials and online support reported significantly more positive attitudes towards the use of the pedometers. Finally, Bourgonjon, Valcke, & Schellens (2010) found that students' perceptions of the technology's usefulness and ease of use were the most important predictors of a students' acceptance of the tools. None of the studies measured fitness. Still, the reasoned hypothesis would be that with increased physical activity levels, so too comes an increase in fitness (Centers for Disease Control [CDC], 2015).

Fulmer (2014) discusses the concept of using perceived autonomy as an additional factor in improving a child's physical activity. If children believe that they are capable of doing an activity, they may feel a greater sense of perceived autonomy. The Fitbit, a self-monitoring system, may help meet this need. The Fitbit offers direct and immediate feedback. Thus, as part of this study, the Fitbit groups received immediate as well as weekly tabulated feedback to monitor their own progress and the progress of their classmates. Additionally, the Fitbit Challenge, used with the PAEB-C group, asked students to set their own individual goals each week with regards to specific physical activity measures.

Using Fitbits to improve SDT. A systematic review done by Lubans, Morgan, and Tudor-Locke (2009) found that in studies using step-tracking devices, twelve out of fourteen studies revealed statistically improved increases in physical activity. In ten of the studies, students were encouraged to use self-monitored activity as a way to increase physical activity, and eight indicated improvements in physical activity steps overall (Lubans et al., 2009). Though the Actigraph has been more widely validated as a measure of physical activity (Welk et al, 2012), Fitbit devices are now being used to monitor children's steps or distance (Keskinen et al., 2014; Pachucki et al., 2015). Unlike the Actigraph, Fitbit devices can be used in combination with social media, which may offer a way to safely track physical activity along with other fitness habits and distribute it to families (Kinnunen et al., 2015). This is important, since three other studies, which tracked fitness habits in addition to steps seen using a pedometer, resulted in improvements in both steps taken and in health-related behaviors (Horne et al., 2009; Lubans & Morgan, 2008; Lubans et al., 2009).

Lubans (2014) notes that, although technologies may not be a solution to our global health epidemic, they could be a way to facilitate behavior change at an individual level. The Fitbit is specifically designed to work at the individual level by be used to providing detailed personalized data, such as minute by minute data and composite data on steps, distance traveled, MVPA, heart rate, and intensity. Therefore, the Fitbit is an ideal tool to facilitate behavior change. Indeed, in a previous study, a group of women, who used the Fitbit along with web-based tracking successfully increase physical activity levels compared to those using a basic pedometer (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015).

To further support the use of Fitbits for the catalyst in this study, it is important to recognize how ingrained these new fitness technologies are in everyday life. More people in general are tapping into resources online to monitor or answer questions related to health (Pai, 2014). Many are turning to new, autonomous forms of technology to create programs as well as to gather information (Consumer Technology Association, 2013). The outcome measures of the technologies are used as a way to help keep track of the physical activities. For example, hospital nurses are now being encouraged to use wireless technology devices to monitor individuals and give feedback (Klasnja & Pratt, 2014; Samples, Ni, & Shaw, 2014). As these devices become more popular, these types of technologies may be able to tap into a child's desires to be a part of everyday society. Additionally, children and parents can choose how much information they want to share with the Fitbit company. However, for the purposes of this dissertation study, students' names and information were never collected and nothing could be used to link the children to their Fitbit data individually or otherwise.

An advantage of using Fitbits is the amount of objective data that can be collected. Teixeira et al.'s (2012) review indicated that most of the studies provided self-reported data for physical activity participation, which can result in skewed results due to a variety of factors, including forgetting to write activity down, or inflating one's own activity statistics as well as others. Since the Fitbit records actual steps, distance traveled, and the amount of time an individual spends in sedentary to moderate to vigorous physical activity (MVPA) it is ideal for objective monitoring. Additionally, Fitbits are hugely popular and are considered a cultural phenomenon (Delgado, 2014). They are now being used to further an individual's engagement, a concept directly related to autonomous regulation seen in SDT (Macey, & Schneider, 2008). Programs that promote employee engagement and motivation have seen great success utilizing similar theory-driven online strategies and Fitbits to help employees monitor their own health (Baxter, Sanderson, Venn, Blizzard, & Palmer, 2014; World Economic Forum, 2009). Therefore, this study should see similar results within the classroom-based setting.

Research Purpose and Hypotheses

The purpose of this study was to investigate the impact of a technology-enhanced physical activity intervention on a child's attitudes and motivation towards physical activity. The study was guided by the following research hypotheses. (1) PAEB-C and Fitbit-O groups will demonstrate higher scores in attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation than the comparison group in the pre-and post-tests. (2) Regardless of the intervention, students with higher average scores for attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation will be more active and less sedentary (examined with the Fitbit data). (3) Regardless of the intervention, students with higher pre-test and post-test scores in attitude and autonomous forms of motivation will have higher post- aerobic fitness than children with lower scores. (4) Pre-test autonomous forms of motivation, attitude and fitness tests can be used to predict a student's post-health-related fitness test scores.

Methods

Research Design

This study used a quasi-experimental design to assign the comparison and experimental schools. The researchers assigned the two classes in the experimental school to intervention conditions: Fitbit Only (Fitbit-O) (N=29) and Physical Activities Engaging the Brain (PAEB) + Fitbit Challenge (C) (N=31). All three groups took pre-and post-tests of the Children's Physical Activity Attitudes and Behavior survey (PAAB). The physical education teacher shared baseline and post- fitness assessment scores (1 mile walk/run and Progressive Aerobic Cardiovascular Endurance Run [PACER] test). These results were classified into Low Fit (LF), Healthy Fitness Zone (HFZ), and High Fit (HF) based on age-specific and gender-specific FITNESSGRAM criteria (Cooper Institute, 2015). The two Fitbit groups received Fitbit Charge Heart Rate Monitors (Fitbits). In addition to being able to check results directly from the watches, composite data for each week was given to the classroom teacher to share with the students. The PAEB-C group also took part in six minutes of physical activities each day during class and they were encouraged to set weekly Fitbit Challenges. This study incorporated feedback strategies for the Fitbit-O and PAEB-C groups, as well as goal-setting strategies for the PAEB-C group and matched them to the comparison group, who maintained their normal school schedule.

Recruitment

This study was conducted in two elementary schools in Michigan in 2015. 116 fifth graders were recruited from five classes on a voluntary basis. Prior to the data collection, approvals from the University of Michigan Institutional Review Board and school district were granted (HUM00102732). Parents were sent home a copy of the study guidelines one week prior to being sent a consent form (see Appendix C). A second letter was sent home if no consent was returned by the end of the week. Parents' consents were secured for the study prior to asking consent of the children. Children were given written consent forms just prior to testing, which were read out loud and which described the purpose of the study and what information the researchers would be gathering (see Appendix D). The study was designed to take seven weeks. The first week was used for recruitment. The second and last weeks were for pre-and post-testing, and the four weeks in the middle were for the intervention. 96.9% from the PAEB-C group, 87.5% from the Fitbit-O group, and 87.7% in the comparison group consented to take part in this study, for a total of 116 participants.

Instruments

Self-Determined motivation. Self-determined (SDT) motivation and attitudes were assessed using a modified Children's Physical Activity Attitudes and Behavior (PAAB) inventory. The PAAB inventory was developed by Chen and Hypnar (2015) and was shortened during a pilot study for the purposes of this study. The PAAB consists of five types of motivational regulations. These include intrinsic motivation, identified regulation, introjected regulation, external regulation, and amotivation. It also includes five perception subscales: attitude toward physical activity, perceived autonomy, perceived competence, and perceived control. Each variable contains three or four items with a 5-point rating scale. These range from 5= strongly agree to 1= strongly disagree. The inventory was validated with third through fifth grade students in the study done by Chen and Hypnar (2015). Prior to administering the PAAB, the participants were encouraged to stop the examiner if they found a question they did not understand. Then each question was read twice by the examiner to insure participant reading comprehension. Children took the inventory during weeks 2 and 7 of the study. Because students were informed prior to the study, as a part of gaining consent, that they would be receiving the Fitbits, this was taken into consideration when designing hypothesis 1, that PAEB-C and Fitbit-O groups will demonstrate higher scores in attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation than the comparison group in the pre-and post-tests. As a result of knowing that they would receive Fitbits, the hypothesis took into consideration the impact this would have on their motivation during both the pre-and the post-test.

Fitbits. Fitbit Charge Heart Rate monitors (Fitbits) were given to students in both Fitbit groups. These devices use a non-invasive wireless sensor on the wrist to measure heart rate and an accelerometer to measure steps and distance traveled. Fitbits have been found to be reliable and easy to use (Kooiman et al., 2015; Lee, Kim, & Welk, 2014). The Fitbits also calculate sedentary, light activity, fairly active, and very active minutes. This is based upon the World Health Organization (WHO, 2015) Metabolic Equivalents (METs). These are used to determine resting and working rates for sedentary behaviors like sitting (1 MET), light activity minutes (1-3 METs), fairly active (3-6 METs), and very active (6 METs). In order to prepare students for wearing the Fitbits, instructions were read regarding the care and maintenance of the Fitbits (see Appendix A). This included what information (steps, distance, floors, and heart rate) was provided by the Fitbits and how to charge them. It also encouraged students to avoid getting them wet. Children were encouraged to wear the Fitbits, but they were also told they were allowed to take them off.

As the students put on the Fitbits, they were told that the Fitbits would buzz for two reasons. First, if they took 10,000 steps and second, if they turned on the timer function. PAEB-C students were also informed of the daily and weekly challenges. The Fitbit Challenges came in the form of a log sheet, on which students were encouraged to record their physical activity to meet their weekly fitness challenges. The challenges included: counting steps and setting a goal, estimating how many steps the whole classroom would take, setting a goal based on distance (miles), and a climbing challenge (floors) (see Appendix B). Each week, during the intervention, teachers were given reports that showed weekly averages for steps, distance traveled and floors climbed for their classes. Children were also reminded of the purpose of wearing the Fitbits during their biweekly physical education classes. All of the Fitbit school teachers were invited to wear Fitbits, but only the Fitbit Challenge teacher and the physical education teacher chose to wear them throughout the duration of the study. Data from the Fitbits was excluded from analysis for two reasons: if the students took fewer than 1000 steps/day and second if they wore the Fitbits for less than 840 minutes. This resulted in the removal of an average of 3.97 (+/-4.83) steps and .72 (+/-1.19) minutes from the Fitbit-O group and 1.87 (+/- 2.21) steps and .90 (+/-1.56) minutes for the PAEB-C group over the duration of the study. A total of 1140 valid days were used in the dissertation out of 1200 total Fitbit intervention days. This averages out to be 1 day lost out of 20 per person, ranging from 0 to 6 days lost per person.

Fitness assessment. All students took part in an aerobic fitness measure as a part of the Fitness Gram, which is assessed at both schools. The researcher used only the scores of the students who had provided consent. Health-Related Fitness Zones (HRFZ) were determined using two fitness assessments the mile was used by the comparison group and the Progressive Aerobic Cardiovascular Endurance Run (PACER) by the Fitbit groups. Both tests are used in the FitnessGram to provide an estimate of aerobic fitness (Cooper Institute, 2015). Based upon these standards, the students were placed into three categories specific to their individual fitness assessment: Low Fit (LF), Healthy Fitness Zone (HFZ) and High Fit (HF).

Procedure

During the second and third week of October, informational and consent letters went home to families (Appendix C). Pre-testing was completed during the third week of October for both schools, and at this time the Fitbit school students received their Fitbits with an assigned number. They wore these for four weeks, and children in the PAEB-C also took part in six minutes of daily physical activity. These were completed 17 times over the course of the semester, once a day after the children had been seated for a time greater than 20 minutes. On Fridays, students placed their Fitbits on the charger for the weekend. Data were collected and uploaded onto the Fitabase software after the students had left the school. Fitabase is a password-protected data management software that is accessible only by the research and management staff (Small Steps Labs, 2015). Teachers were made aware of which Fitbits had not been returned and were given class-averaged data (steps, distance and floors) to share with their students.

After four weeks the Fitbits were collected and the missing Fitbits were recorded. This information was shared with the teachers to see if it could be recovered. One Fitbit was destroyed and two were not returned; however, data were still retrievable from all three. During week eight of the study the students took the PAAB for a second time. Once the study was completed, before recording any data, in order to separate the groups by study design the students were then given two more numbers based upon which group they were in (comparison, Fitbit-O or PAEB-C). Each student was also given a two-digit number for identification purposes, but otherwise the data were anonymous.

Data Analysis

All of the statistical analysis was conducted using Windows SPSS version 22. Statistical significance was determined when $p < .05$. An exploratory factor analysis was conducted on the pre-test PAAB data[1], which generated three factors: (Self Perception (SP), Autonomous Motivation and Attitude (AMA), and Controlled Motivation (CM)). There were no specific criteria for number of items for each factor, but they were added only if they had a loading coefficient of greater than .600. These items were then averaged without factor scores. The variable for sedentary minutes was recalculated by using the sedentary METs data minutes and subtracting nine hours a night for sleep (WebMD, 2016). Finally, a variable was created that combined very, fairly and light activity minutes over the total number of minutes.

Hypothesis 1: PAEB-C and Fitbit-O groups will demonstrate higher scores in attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation than the comparison group in both the pre-and post-tests. To examine if there were significant changes between the pre-and post- factor variables (SP, AMA, and CM) a repeated MANOVA, controlling for gender and race, was completed using averages of each variable. The MANOVA was analyzed to see if there was a significant decrease or increase in

[1] A further discussion of what data were used to develop the factor analysis is in the "results" section, below

motivation from pre-to post-test for attitude and motivation. No change was expected. Additionally, the factor variables were also compared between subjects by groups. An ANOVA method was used to examine if there was a significant difference between the three groups (PAEB-C, Fitbit-O, and comparison) for the averages of each of the three dependent factor variables, also controlling for gender and race. When significant differences were found between the three groups, a post-hoc comparison method was conducted to examine if there was a significant difference between the PAEB-C and Fitbit-O, the PAEB-C, and the comparison, and the Fitbit-O and the comparison groups. Those factor variables that were significant (SP and AMA) were broken back down into the PAAB subscales to see what specific variables ([AMA=intrinsic, identified, and attitude], [SP = autonomy, perceived control, and perceived competence]) were significant. Additionally, the two schools were compared using an ANOVA, to see if having the Fitbit regardless of intervention type increased motivation.

Hypothesis 2: Students with higher pre-test and post-test mean scores for autonomous motivation and attitude (AMA) and self-perception (SP) will be more active and less sedentary than children with lower scores for AMA and SP. A correlation matrix was run to compare the factors for AMA, SP, and CM with the amount of physical activity from the Fitbits. The subscale variables from the PAAB (AMA and SP) that were significant were also correlated to the Fitbit data to see which specific variables were significantly related to physical activity.

Hypothesis 3: Students with higher pre-test and post-test mean scores in AMA and SP will have higher aerobic fitness than children with lower scores for AMA and SP. The factor variables (SP, AMA, and CM) were compared to the results from the post- fitness test. Variables that continued to show significance were further broken down into their subscales (intrinsic, identified, attitude, autonomy, perceived control, and perceived competence). These were also compared to the post-test health-related fitness zones (HRFZ).

Hypothesis 4: Autonomous forms of motivation and attitude can be used to predict a student's changes in health-related fitness from pre-to post-test. Finally, a stepwise regression was used to find the best fit between the HRFZ and the factor variables. This was used to determine if the pre-tests for SP, AMA, or CM could be used to explain a change from pre-to post-test in an individual's fitness levels. No changes in motivation were found from pre-to post-test for attitudes and motivation (see hypothesis 1). Therefore, the pre-test was used as the first factor for predicting post- fitness, followed by AMA, SP, and CM. Those that were significant were further broken down into the subscales for the PAAB (intrinsic, identified, attitude, autonomy, perceived control, and perceived competence) and the calculations were run again using those variables.

Results

In order to examine motivation and attitude scores for the three study groups, a factor analysis was examined and three categories were created. Factor 1 loaded with autonomy (.829), perceived control (.814), and perceived competence (.635) and was called Self Perception (SP). Factor 2 loaded with attitude (.769), intrinsic motivation (.761), and identified regulation (.695) and was called Autonomous Motivation and Attitude (AMA). Factor 3 loaded with extrinsic (.801) and introjected (.789) and was called Controlled Motivation (CM).

Hypothesis 1: PAEB-C and Fitbit-O groups will demonstrate higher scores in attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation than the comparison group in both the pre-and post-tests. As expected there were no pre-to post-test differences in the factor variables for SP, AMA and CM when a repeated measure MANOVA, controlling for gender and race was examined. The MANOVA did reveal a significant difference between the three groups (F = 5.959, p = .001). A further analysis using an ANOVA, controlling for race and gender, found that AMA (F = 5.02, p =.008) and SP (F = 5.01, p = .008) were significantly higher in the Fitbit Groups but that there were no significant findings for CM (F = 1.171, p = .314). A post hoc analysis, controlling for gender and race, revealed that no pre-to post-test differences were found between any of the three groups. There was a significant difference between the PAEB-C and the comparison groups (F = 6.276, p = .001) but no overall difference between Fitbit-O and comparison groups (F = 2.093, p = .108). Differences were found in the post hoc test for the individual factor variables between the PAEB-C group and the comparison for AMA (F = 6.432, p = .013) and SP (F = 8.304, p = 005), as well as for AMA (F = 4.590, p = .035) and SP (F = 3.185, p = .078) when the Fitbit-O and comparison groups were compared (see Table 5.1).

Table 5.1 Post hoc comparison between the groups by the factor variables

Groups	PAAB Measure	df	F	Sig.
Fitbit Only By Comparison	AMA	1	4.590	.035
	SP	1	3.185	.078
	CM	1	.004	.949
PAEB-C By Comparison	AMA	1	6.432	.013
	SP	1	8.304	.005
	CM	1	2.238	.138
PAEB-C By Fitbit Only	AMA	1	.065	.800
	SP	1	.675	.415
	CM	1	1.919	.171

Autonomous Motivation and Attitudes (AMA), Self -Perceptions (SP) and Controlled Motivation (CP)

This supports the hypothesis that both Fitbit groups had higher average attitudes and autonomous forms of motivation than the comparison school throughout the four-week intervention, but it did not show them to have lower scores for more controlling forms of motivation. Both groups also showed little to no change from pre-to post-test in their motivation scores, which is also important since this indicates that the scores stayed higher for the Fitbit groups without a significant change from pre-to post-test. When the subscales for SP (autonomy, perceived competence, and perceived control) and AMA (intrinsic, attitude, and identified regulation) were compared using a post hoc analysis between each subset of groups significant differences were also found. The PAEB-C children scored significantly higher than the comparison group on averaged pre- and post-scores for intrinsic ($F=4.037$, $p = .048$), perceived competence ($F = 4.535$, $p = .036$), perceived control ($F= 6.866$, $p = .010$), attitude ($F = 7.509$, $p = .008$), and autonomy ($F = 6.056$, $p = .016$). Like the PAEB-C the Fitbit-O children scored higher on means scores for perceived competence ($F = 5.916$, $p = .017$) and attitude ($F = 4.316$, $p = .041$), but not on the other variables. Children in both Fitbit groups had higher average attitudes and perceived competence pre-and post-test scores than the comparison group, but only children in the PAEB-C group scored higher on their pre- and post- intrinsic motivation, perceived control, and sense of autonomy. When the Fitbit school was paired with the comparison school, both AMA ($F = 9.385$, $p = .003$) and SP ($F = 8.037$, $p = .005$) were significantly higher in the Fitbit school than the comparison school, and the following PAAB subscale variables were significant: intrinsic ($F = 6.310$, $p = .013$), identified regulation ($F = 4.118$, $p = .045$), perceived competence ($F = 7.885$, $p = .006$), perceived control ($F = 6.404$, $p = .013$), and attitude ($F = 10.167$, $p = .002$). Both minority status and gender are not significant independently, but when they are factored into the analysis, the group effect becomes even more pronounced for AMA ($F = 5.003$, $p = .080$) and SP ($F = 4.870$, $p = .010$). Separate from the group affect, a minority child’s motivation increased in both intervention groups, but AMA was the most pronounced improvement: not significant ($F = 3.302$, $p = .07$) trending in a positive direction.

Hypothesis 2: Students with higher pre-test and post-test mean scores for autonomous motivation and attitude (AMA) and self-perception (SP) will be more active and less sedentary than children with lower scores for AMA and SP. A correlation matrix revealed a significant relationship between the pre-test for SP and fairly active minutes (p=.048), but no other relationships were found. However, when the correlation matrix was used to compare the Fitbit data with the subscales for the PAAB, a child's attitude towards physical activity was positively related to light activity minutes (p = .046), as well as a ratio of very, fairly, and light activity/total activity minutes (p = .029). It was negatively associated with sedentary minutes (p = .013). Gender was not associated with any of the SDT or attitude variables, but minority status was associated with lower scores in SP compared to their non-minority peers (p = .012).

Hypothesis 3: Students with higher pre-test and post-test mean scores in AMA and SP will have higher aerobic fitness than children with lower scores for AMA and SP. Table 5.2 compares the pre-test means from AMA, SP, and CM to the post-fitness scores (LF, HFZ and HF). Significant differences were found in the means for SP (p = .003) and AMA (p = .002) between individuals who were more fit compared to their less fit counterparts. It was also found that children in the Healthy Fitness Zones at the post-test had the highest overall mean scores for AMA (p = .002) and SP (p = .003).

Both AMA and SP were broken into their subscale variables, and the following variables, intrinsic, perceived competence, perceived control, and attitude, were significantly higher for children in the HFZ and HF groups (see Table 5.3).

Table 5.2 Comparison of the Mean Scores for Autonomous Motivation, Self-Perception and Controlled Motivation with Health-Related Fitness Zones (HRFZ).

HRFZ		Autonomous Motivation and Attitudes (F = 6.895, p = .002)	Self-Perception (F = 4.882, p = .003)	Controlled Motivation (F = .383, p = .661)
Low Fit	Mean	4.336	3.3404	2.8234
	(Std. Deviation)	(.56655)	(.97721)	(.95161)
Healthy Fitness Zone	Mean	4.6931	3.9648	2.9970
	(Std. Deviation)	(.29252)	(.78309)	(1.02982)
High Fit	Mean	4.4048	3.6984	2.8393
	(Std. Deviation)	(.48216)	(.71927)	(.43129)

Table 5.3 Comparison of the Mean Scores for the Significant Subscale Variables with Health-Related Fitness Zones (HRFZ).

HRFZ		Intrinsic Motivation (F = 8.185, p = .000)	Perceived Competence (F = 7.785, p = .001)	Perceived Control (F = 4.290, p = .016)	Attitude (F = 5.106, p = .008)
Low Fit	Mean	4.0794	3.1905	3.52	4.4246
	(Std. Deviation)	(.87624)	(1.20292)	(1.113)	(.51906)
Healthy Fitness Zone	Mean	4.6707	4.0732	4.11	4.7134
	(Std. Deviation)	(.42734)	(1.03953)	(.822)	(.34714)
High Fit	Mean	4.3571	3.8095	3.62	4.3929
	(Std. Deviation)	(.64319)	(.87891)	(1.044)	(.55635)

Hypothesis 4: Autonomous forms of motivation and attitude can be used to predict a student's changes in health-related fitness from pre-to post-test. Finally, three stepwise regression models were conducted to determine to what extent three factor variables (AMA, SPc and CP) contributed to children's aerobic fitness. Results indicated that the pre-test for HRFZ, AMA and SP were the overall best fit (F = 30.984, p = .000) to explain the outcomes for the post- fitness results. The extrinsic motivation variable was eliminated from the model. When

individual predictors were analyzed, the pre-test for HRFZ (β = .637, t = 8.62, p = .000), AMA (β = .116, t = 1.447, p = .151) and SP (β = .167, t = 2.075, p = .040) entered into the model (F = 6.469, p = .000). Model 3 accounted for 46.5% of the variance in HRFZ, 6% of which could be predicted by the AMA and CP variables. The other 40% was predicted by the pre-test for fitness. When the subscale variables from the PAAB were used in the stepwise regression, two variables —intrinsic and perceived competence —emerged as being significant in the overall fit alongside the pre-test for fitness (F = 32.850, p = .001). This model accounted for 47.9% of the variance in HRFZ, with intrinsic and perceived competence accounting for 7.2% of the difference in variance.

Discussion

Hypothesis 1: PAEB-C and Fitbit-O groups will demonstrate higher scores in attitude and autonomous forms of motivation and lower scores in more controlling forms of motivation than the comparison group in both the pre-and post-tests. Weiss (1993, 2013) argues that perhaps more effort needs to be placed on motivating children to participate in physical activity. This study confirms this by finding a direct relationship between improved attitudes and autonomous forms of motivation and increased fitness levels. The present results of this study indicated that AMA and SP scores were significantly higher for the Fitbit-O and PAEB-C groups than the comparison school. The introduction of the Fitbit, regardless of PAEB-C or Fitbit-O condition, improved a child's outlook on physical activity; particularly in the areas of intrinsic, perceived competence, and attitude. In addition to these improvements, the PAEB-C intervention also improved a child's autonomy and perceived control towards physical activity. This finding is consistent with other studies that introduced new technologies to students (Gao et al., 2013; Gao et al., 2012; Quin, 2013; Zhang & Stodden, 2013). Students who were introduced to the DDR and aerobic dance reported enjoying the DDR at much higher levels than aerobic dance (Zhang & Stodden, 2013). Mikkola et al. (2010) used a similar approach by introducing Polar monitors. As a result of this introduction students were made more aware of their own progress through continued monitoring and afterwards reported higher motivation to be physically active (Mikkola et al., 2010).

However, the present results differ slightly from studies reviewed by Teixeira et al. (2012), who found that identified regulation was consistently found to be significant more often than intrinsic motivation in studies that focused on increasing physical activity while monitoring motivation. This study did find that identified regulation became significant when the two schools were compared overall to the comparison group, but it was not directly related to increased physical activity. This may be a result of the intrinsic nature of the Fitbits and their popularity in present culture. The appeal of the Fitbits may be more related to a child's enjoyment and fun rather than the process of fully assimilating the Fitbits as part of their own identity (Deci, & Ryan, 1985). However Teixeira et al. (2012) also suggest that all of the motivation factors are very similar on the continuum and, therefore, the results found in this study can be interpreted as supporting the previous literature.

In addition to improvements in SDT, students' attitude scores were also much higher in the Fitbit groups. Stelzer (2005) suggests that a change in attitude may be even more important than just increasing physical activity. His study finds that a student's participation in physical activity may improve the child's attitude towards more than just physical activity. He proposes that the physical activity may also make the child's feelings towards school more positive (Stelzer, 2005). De Cocker et al. (2008) recorded similar results. They found that attitude changes were also directly related to feedback materials, which significantly increased an individual’s attitudes towards physical activity and their perceived attitudes towards the use of pedometers (De Cocker et al., 2008). In the intervention discussed in this paper, the Fitbit provided constant feedback for the children for heart rate, steps, distance, and floors climbed. If they reached their goal it buzzed, letting them know they had taken the recommended number of steps. However, the PAEB-C went one step further. Students did six minutes a day of activities in the classroom. Plus, they were encouraged to self-monitor and assess the feedback through the Fitbit Challenge worksheets, in addition to just looking at the Fitbit results. However, since children’s attitudes improved in both Fitbit groups regardless of the intervention strategies, just having the Fitbit to check data may prove to be enough feedback to get kids to start thinking differently about physical activity. It may also explain why there was a much larger effect found between the PAEB-C and the comparison group in the post hoc tests than when the Fitbit-O group was paired with the comparison group. The increased emphasis on feedback, and the daily six minutes of physical activity may also have acted to increase the PAEB-C student’s intrinsic motivation and perceived autonomy. This supports the findings of Cadmus-Bertram et al. (2015): the women in the study cited increased feedback as the reason for liking the Fitbit’s more than basic pedometers.

In this study children also showed improvements in perceived competence and perceived control over the comparison school. Since these types of motivation can be driving forces behind whether or not a child participates in physical activity (Teixeira et al, 2012), this is a promising finding. If children perceive themselves to be able to choose what activity they do, and or considers themselves to be good at the activity, this may initiate autonomous forms of motivation (Fulmer, 2014). A review by Owen et al. (2014) found this to be the case. Students who reported feeling a lack of control were less likely to be active.

Hypothesis 2: Students with higher pre-test and post-test mean scores for autonomous motivation and attitude (AMA) and self-perception (SP) will be more active and less sedentary than children with lower scores for AMA and SP. The results were not entirely conclusive with regards to hypothesis 2. The results for the extrinsic factors were not significant, but in all cases the data did trend in the expected direction, where more positive AMA and SP equated to more activity and increased sedentary behaviors were found with elevated controlling forms of motivation. However, only a few of the results were statistically significant. When the physical activity data were broken down into the PAAB subscales, the results were clearer. A positive attitude towards physical activity was directly related to more light activity minutes. Conversely, the worse a child's attitude was towards physical activity, the more sedentary minutes they got. These results may have been directly affected by the study itself, since students in both Fitbit groups knew they were going to get Fitbits and adding the Fitbits was meant to increase autonomous motivation and perceived relatedness for the students. The resulting increase for AMA and SP in the Fitbit groups was much higher than in the comparison group, regardless of fitness level. This may have been expected, but since the comparison school had significantly lower motivation (Hypothesis 1) but higher fitness (Chapter 4) this may explain why the results were skewed in the high fitness zones and may indicate that the relationship may have been stronger without these confounding factors. Therefore, the dissertation study itself may have inflated scores in the Fitbit groups (hypothesis 1) for children who were normally not very active at all. Seghers et al. (2014) found that step count for students in a cross-sectional study was directly related to a child's intrinsic motivation. Mayorga-Vega and Viciana (2014) found that children with higher motivation scores were more likely to reach the recommended physical activity levels (Mayorga-Vega, & Viciana, 2014). Since this study manipulated the child's motivation through the introduction of the Fitbits, and steps increased to an average of 10,000 a day, the lack of more direct correlations between motivation and step count or activity minutes is not surprising. To find a more accurate result, another study should follow up on the students after the recommended eighteen week period (Sun, 2013) to see if motivation levels fluctuate or whether steps and activity minutes changed (Zhang, & Stodden, 2013).

Hypothesis 3: Students with higher pre-test and post-test mean scores in AMA and SP will have higher aerobic fitness than children with lower scores for AMA and SP. The results were more conclusive for the third hypothesis. Still, they cannot be totally explained by the data alone. On average, students who had higher scores for attitude and autonomous forms of motivation were more likely to fall into the two higher fitness zones, HFZ and HF. However, children in the HF group scored lower for AMA and SP than children in the HFZ. This does not seem to make sense except when the data are further analyzed. No students in the Fitbit groups scored an HF on the pre-or the post-test of the HRFZ. This is important to recognize, since the scores highlight the intervention effect on attitudes and motivation towards physical activity (Hypothesis 1). If the intervention can improve motivation and attitudes towards physical activity, and this can be used to impact fitness, this may be an excellent approach to introducing new intervention strategies. The new emphasis would be to motivate children to want and like physical activity, so they then choose to be active. This was the goal of using the Fitbit, a technology that already is popular. This concept is supported by the findings in Teixeira et al. (2012). In their overview of exercise and self-determination, they found that sustained exercise is directly related to autonomous forms of motivation, with intrinsic and identified motivation factors being the best indicators over a longer period of time (Teixeira et al., 2012). What they found, which is different than the results of this study's findings, is that the most other research that examined autonomous forms of motivation used it as the outcome variable, instead of the driving factor. Additionally, Teixeira et al. (2014) noted that only a few studies directly looked at the relationship between SDT and fitness. Since the results appear to support a positive relationship, further studies should introduce factors to increase motivation as a part of the intervention.

One such study (Riiser et al., 2014a) found slight increases in aerobic fitness as a result of a targeted SDT intervention. They found that these improvements came for children who also saw increases in their overall fitness levels. A similar result was found for soldiers' motivation in a study by Dyrstad, Miller and Hallén (2007). In this study, they found that the more intrinsically motivated the soldiers were, the higher their levels of fitness (Dyrstad et al., 2007). However, they also found that mandatory fitness activities were detrimental to gaining fitness (Dyrstad et al., 2007). This correlates to what was found in this data, and it may explain why the four variables intrinsic motivation, attitude, perceived control, and perceived competence were directly related to a child's HRFZ. Participating in an activity needs to be a choice made by the individual. Since wearing the Fitbit seems to increase autonomous forms of motivation, this may prove to be a very good way to increase a child's fitness without seeming to force them to do more activity. Conversely, forced sessions may take away the child's feeling of control—as seen with the soldiers (Dyrstad et al., 2007). Since the PAEB activities were done in the classroom each day, this may have also impacted our study. Motivation scores could have been negatively impacted by being asked to take part in daily PAEB activities, and the difference may have been greater in motivation without them in this group.

It is also important to note that since motivation levels were impacted by the intervention (Hypothesis 1), the relationship may actually be even more directly related to fitness than is seen in this study, since the comparison group was included in the analysis. Since motivation levels are inflated due to the intervention effect in the Fitbit school it may be prudent to examine levels pre- to post- only in students who did not take part in any fitness intervention to see if a correlation still exists. It also highlights the potential importance of future studies looking at three Fitbit groups, a Fitbit Only, a Fitbit-Challenge and a PAEB Fitbit-Challenge to see how much each of the different conditions impacts motivation.

Hypothesis 4: Autonomous forms of motivation and attitude can be used to predict a student's changes in health-related fitness from pre- to post-test. Even with the increased motivation scores, a stepwise regression found that higher scores for attitude and autonomous forms of motivation was predictive of increased fitness alongside the pre-test of the HRFZ. Two factors accounted for 6% of the variance in HRFZ at the post-test: AMA and SP. To further understand this finding, the significant subscales from the PAAB were also used in the stepwise regression. Intrinsic and perceived competence emerged as being predictive of HRFZ, and they accounted for 7.2% of the variance. Ntoumanis (2010) explored and found this same relationship in a cross-sectional study. The outcomes indicated that perceived competence was the major psychological factor in determining a child's intrinsic motivation to be active. Therefore, the finding is supported, since both wanting to take part in the activity and a sense of autonomy are strongly correlated to whether or not an individual maintains fitness.

Most studies have examined activity levels, and many of the studies which have examined SDT have used self-reported data or exercise frequency; not an individual's fitness (Teixeira et al., 2012). But the study in this dissertation took it one step further by using motivation as a predictor of fitness. This effect has been seen in only one other study, (Riiser et al., 2014b). In the Riiser study researchers focused on facilitating increases in physical activity by counseling children to help them improve their physical activity goals and health-related outcomes. As a result, they found SDT motivation mediated the relationship between fitness and health-related quality of life (Riiser et al., 2014). Similarly, Graham, Sirard, & Neumark-Sztainer (2010) showcased this in their longitudinal study. Graham et al. (2010) found that attitudes towards physical activity were predictive of future MVPA in individuals five and even ten years later (Graham et al., 2010). This is the purpose of the SDT. It was developed as a way to predict an individual's behavior (Shen, 2014). As a result, the perceived locus of causality may be a reasonable tool to predict the likelihood of an individual participating in physical activity, and therefore becoming more fit (Teixeira et al., 2014). Shen (2014) further suggests that increased physical activity may manifest for the sole purposes of interest and enjoyment, but the study discussed in this paper illustrates that the SDT model as a whole may be a very important tool by which to consider physical activity and fitness. If autonomous motivation, perceived relatedness, and attitude levels can be increased and then maintained, it could prove to be very beneficial for students over the span of their lifetimes.

Limitations

Several limitations are noted in this study. The participant selection may have limited the generalizability of the results of this study. The students in the Fitbit school were less fit during the pretests than the comparison school. The schools were mostly matched by race and SES, but, two other schools may have been better suited to be paired with the Fitbit School (see Appendix E). Unfortunately, the district was already involved in other programs at these other schools, which may have affected the outcomes (School District Demographics System, 2014).

The Fitbit Challenge was also meant to be used in both of the Fitbit classrooms. The Fitbit-O teacher opted out of taking part in this aspect of the study. The study had originally called for a Fitbit Challenge and a PAEB-C group, so adjustments were made to accommodate this. This made it difficult to differentiate the impact of the Physical Activities Engaging the Brain activities from the Fitbit Challenge. However, to understand how this may have impacted the students in the PAEB-C group. Students in this group were asked rate their enjoyment of the PAEB activities at the end of the study, and their reactions were mixed. Very few said they really liked or hated them. A few said that they tried them at other times throughout the day and even at home. Thus, this seems to show that the students did not feel like they were being forced to do the activities, nor did it significantly impact their daily physical activities. Another problem that arose during the study was that both schools were originally going to do the mile assessment. However, during the testing period, the Fitbit School's outdoor area was closed for construction, therefore they agreed to do the PACER test instead. Still, both tests are used as aerobic distance measures on the Fitness Gram, so the results were converted to this per these guidelines (Cooper Institute, 2015).

Finally, during the IRB process, the approval was contingent upon the informational letters telling both parents and children that they would be receiving and would be expected to wear the Fitbit throughout the duration of the study. The original hypothesis had been to do a pre-and post-test comparison, without the children knowing about the Fitbits, to see if they were more motivated from pre- to post-test. This was not possible, and so the hypothesis was changed to reflect the excitement that was expected to be seen on the day of the pre-test for the PAAB. Future studies could mitigate this by doing do an assessment of motivation before the participants find out they are getting the Fitbits or to mention only that they are going to get an activity monitor. Additionally, it was suggested that a more longitudinal study be completed in order to see how long the increased motivation lasts beyond the first month.

Conclusion

A child's improved attitude and autonomous forms of motivation to be physically active were shown to be an important component relative to their level of fitness and their likelihood of taking part in physical activity. The introduction of the Fitbit alone was enough to increase a child's fitness, over the course of four weeks, during what can sometimes be a seasonal period of decline. Increasing a child's self-perceived, autonomous motivation and attitudes with autonomous challenges and a Fitbit, both improved fitness and got children to do significantly more physical activity and be less sedentary. In addition to finding improvements in fitness, this study found that attitude and autonomous forms of motivation could be predictive of changes in fitness. This feasible and easy-to-run intervention presents a realistic option for increasing children's fitness in schools. This study has also shown that adding an easy-to-use Fitbit intervention to classrooms resulted in increased physical activity levels which were facilitated by the children's own perceptions of physical activity. These findings are consistent with other research, but they add a new element to the research: a contributing link between a child's autonomous motivation and attitudes (AMA) and self-perceptions (SP) and increased fitness. To further explore this relationship, a longitudinal study should be completed to see how long the changes in motivation continue. Future studies should also look at whether students revert back to pre-trial motivation or attitudes towards physical activity or whether some of the changes continue to be exhibited even after the intervention is complete. And since the results appear to support a positive relationship between adding physical activity motivators (like the

Fitbit and Fitbit Challenges) further, studies should introduce factors to increase motivation as a part of their intervention strategies.

Chapter 6

Dissertation Conclusion

In America cardiovascular fitness levels are declining as more and more individuals are increasingly sedentary (AHA, 2015). In order to present evidence that would support adding physical activity to classrooms four key concepts have been examined. These concepts include targeting: (1) physical activities that engage the brain for improved executive functioning, (2) Fitbit-enhanced physical activities based on autonomous motivation and perceived relatedness to improve children's motivation, (3) motivationally driven challenges to increase physical activity and (4) fitness. This is the first study to show the benefits of using a Fitbit-based intervention to promote executive function, fitness, and physical activity in a classroom. It is also the first of its kind to use a classroom setting to examine how motivation can be improved and then that motivation used to improve fitness and physical activity. The results indicate that: (1) classroom-based coordinated bilateral activities of a short duration each day (six minute video) alongside a Fitbit Challenge could feasibly and easily be introduced into a classroom, and that this intervention was successful at eliciting improvement in a student's executive function. It also indicated that: (2) physical activity promoted through short classroom breaks and perceived autonomous challenges was successful at promoting and improving fitness. Finally (3) this study is the first study to demonstrate that a relationship exists between a child's autonomous forms of motivation and self-perception and the child's Health-Related Fitness Zones. Therefore, future studies that can replicate or expand upon these findings should be completed to provide further evidence that a direct link exists between physical activity, motivation to be active, and executive functioning. Once established, this could be the impetus for more mandates to include physical activity in the schools, particularly in the classrooms.

Still limitations discussed in the previous chapters may act to mitigate the strength of the findings in this study. Therefore, future studies should consider the following changes. The intervention should be expanded to a larger study group over a longer period of time, using groups that are matched and blindly chosen for intervention versus comparison status. In future studies, I recommend that both fitness tests be used to create a more representative HRFZ for each child and that four groups be used to measure the differences between the Fitbit Challenge, Fitbit only, physical activities engaging the brain and a comparison. Additionally, since the results of this study support that a relationship exists between adding physical activity motivators and increasing physical activity and fitness, future studies may want to be sure to include motivational strategies to drive the intervention. Finally, to determine how much of the impact is “Fitbit”, a future study may want to examine other devices to see to what extent each may impact a child’s motivation and for how long.

Still, this research indicated that this type of intervention can be successfully implemented in classrooms to promote physical activity, increase fitness, improve motivation and attitudes and promote executive functioning. Also, it proved to be effective and easy-to-run as well as non-invasive for the classroom teachers. Therefore, emphasis should be placed on insuring that future studies are completed using the Fitbit and similar motivational strategies. With no professional development, this type of easy-to-run intervention can also be easily adapted into more districts without significant additional costs. Additionally, since this intervention results in more attentive children and little-to-no additional work for the teachers, the teachers may be more likely to choose to opt in to this type of program to promote physical activity in their classroom.

Appendices

Appendix A

Using Your Fitbit

Exercise Your Mind, Mind Your Motivation

Look at the face of the band. Now, next to the face of the Fitbit Charge HR, there is a button. When you press this it will show you a new image. First it will show you a clock.

Measures the number of steps you take

: Measures your heart rate

Measures the number of floors you have climbed.

Measures how far you have gone in miles

Measures how many calories you have burned.

Keep it Clean: Regularly clean your band and wrist—especially after working out or sweating. Rinse the band with water or wipe it with a small amount of rubbing alcohol. Do NOT use hand soap, body soap, dish soap, or household cleaners which could get trapped beneath the band and irritate skin. Always dry the band well before putting it back on. While Fitbit devices are water resistant, it's not good to keep a wet band on your skin for long periods of time.

Keep it Dry: If your band gets wet—like after sweating or showering—rinse and dry it thoroughly before putting it back on your wrist. Be sure your skin is dry before you put your band back on.

Not too tight: Make sure your band isn't too tight. Wear the band loosely enough that it can move back and forth on your wrist. Since we are using a Charge HR you can get a better heart rate reading during exercise if the band is secure, but not too tight, and wearing the band higher on your wrist (about 2-3 finger widths above your wrist bone). But remember to lower the band on your wrist and loosen it after exercise.

Rest your wrist: Prolonged rubbing and pressure may irritate the skin, so give your wrist a break by removing the band for an hour after extended wear. Please however, remember to put it back on and to wear it to school each day.

Have fun!

Appendix B

Fitbit Challenge

Week 1: Challenge yourself to take at least 10,000 steps today and each day this week. To find  out how many steps you took, look at the image, then keep track all day and see if you can take 10,000 steps. Write down the number of steps you take each day. Try and see if you can find your average number of steps in a week.

Day 1:__________________ Day 3: __________________ Day 5: __________________

Day 2: __________________ Day 4: __________________ Total: __________________

Week 2: What was your average number of steps during week 1? Guess how many steps you  can take this week. Write this number down. Guess how many steps the whole class will take. Each night write down the number of steps you took that day. Now add up how many steps you took during the whole week. This week, I also want you try and look at the Heart rate image each day at least three times. When does it beat the fastest? The slowest?

How many steps you think you can take in a week? ______________________________

Day 1:__________________ Day 3: __________________ Day 5: __________________

Day 2: __________________ Day 4: __________________ Total: __________________

Week 3: How many steps did you take? How many steps did your class take? This week, we will  be focusing on climbing up high. Have you ever climbed a Mountain? This is your chance to see how high you and your classmates can climb in a day? In a week? Write down the number of floors you climb tonight and each night thereafter, the class will add them up to see how high we have climbed. Do you think we can climb to the top of the Sears Tower? Mount Everest?

Sears Tower: 108 Floors (*1,450 feet)* Mount Everest: 2163 Floors (*29,029 feet)*

Day 1:__________________ Day 3: __________________ Day 5: __________________

Day 2: __________________ Day 4: __________________

Week 4: Can you walk across Ann Arbor? Michigan? The USA? Estimate how far you think you  can go, or the class can go this week. Hint: 10,000 steps is equal to about 5 miles.

Ann Arbor: 29 miles. Across Michigan: 240 m. To the U.P.: 400 m. Across the USA: 2,092 m.

Day 1:__________________ Day 3: __________________ Day 5: __________________

Day 2: __________________ Day 4: __________________

Appendix C

Study ID: HUM00102742   IRB: Health Sciences and Behavioral Sciences   Date Approved: 7/24/2015

Informational Letter: Exercise Your Mind. Mind Your Motivation

Dear Parents:

Heidi Harris and Weiyun Chen, Ph.D. of the University of Michigan, invite your child to take part in a research study: *Exercise Your Mind, Mind Your Motivation.* You are being contacted because your child attends school in the Ann Arbor Public Schools.

We invite your child to be part of a research study about developing strategies to improve a child's motivation and attention span in a classroom and physical activity setting. The study is funded by the University of Michigan, School of Kinesiology

You are being contacted because your child attends XXX Elementary School in the XXX Public Schools. We would like to work with your child to develop strategies to improve attention and motivation. The purpose of this study is to investigate the impact of a Physical Activity program focused on improving attention and intrinsic motivation. We plan to ask children in 5th in the Ann Arbor Public Schools to participate in our research.

If you agree to allow your child to be a part of this study, your child will be asked to take two sets of tests which measure motivation and attention. The first test is meant to look at how your child feels about physical activity. The second will look at how well they are able to pay attention and to focus. Together the tests take about 15 minutes and they will be given during your child's physical education class. Your child will be given a wrist band with a number on it that says "University of Michigan: School of Kinesiology". They can store this band in their desk. After the study is over they will get to keep the band. The physical education teacher will also be given the number in case they lose their wrist band.

Although your child may not benefit directly from being in this study, it may help researchers understand what helps to keep kids physically active. It will also help us begin to see if there is a link between physical activity and a child's ability to pay attention in class.
The researchers have taken steps to minimize the risks of this study. In order to avoid any the researchers will give each child a number instead of using their name.

Your child will not be paid for taking part in this study.

We plan to publish the results of this study, but we will not be asking for any information in the study that could be used to identify your child.

To keep this information safe, the results of the questionnaires will be kept on a secure server at the University of Michigan. The researchers plan to keep this study data for two years at which time it will be destroyed. There are some reasons why people other than the researchers may need to see information your child provided as part of the study. This includes organizations responsible for making sure that the research is done safely and properly, including the University of Michigan.

Participating in this study is completely voluntary. Even if you decide to allow your child to participate now, you may change your mind and stop at any time. If you decide to withdraw your child early, no further data will be collected. Your child will also be asked for consent. At this time they will be able to choose whether or not to take part in the study.

You will be given two copies of the consent form. Please keep one copy for yourself. Please return the second copy to your child's Physical Education teacher. Please feel free to contact me if you have any questions. My phone number is 734-904-7195 or you may contact me by email at heday@umich.edu

Thank you very much for your time,

Heidi Harris
1402 Washington Heights Ann Arbor, MI 48109
734-904-7195 heday@umich.edu

Please save this document

Informational Letter: Exercise Your Mind. Mind Your Motivation

Dear Parents:

Heidi Harris and Weiyun Chen, Ph.D. of the University of Michigan, invite you to take part in a research study: *Exercise Your Mind, Mind Your Motivation.* You are being contacted because your child attends school in the Ann Arbor Public Schools.

We invite your child to be part of a research study about developing strategies to improve a child's motivation and attention span in a classroom and physical activity setting. The study is funded by the University of Michigan, School of Kinesiology

You are being contacted because your child attends XXX Elementary School in the XXX Public Schools. We would like to work with your child to develop strategies to improve attention and motivation. The purpose of this study is to investigate the impact of a Physical Activity program focused on improving attention and motivation. We plan to ask children in 5^{th} grade at Carpenter to participate in our research.

If you agree to allow your child to be a part of this study, your child will be placed into one of two groups. Both groups will take two sets of tests to measure motivation and attention.

Both groups will be given a Fitbit Charge to wear for four weeks. This will collect the amount of physical activity, the Heart Rate and the amount of sleep your child gets. Your child will be asked to wear the Fitbit every day for five days, Monday through Friday. But not when it might get really wet, like swimming. It is ok to take it off at any time. You may also give it back to us if your child does not want to wear it. If it gets lost or stolen we will not charge you or your child.

One group will take part in Physical Activities Engaging the Brain (PAEB). The PAEB are a series of six minute low to moderate physical activities and physical movements that are targeted to stimulate the brain. These are very low intensity activities. If your child is in this group they will do these activities each day in class for four weeks.
Although your child may not benefit directly from being in this study, they will probably enjoy the videos and the exercise.

The researchers have taken steps to minimize the risks of this study. In order to avoid any the researchers will give each child a number instead of using their name. Some other risks, even when the researchers are careful to avoid them, may be present.
There will be no financial compensation. We plan to publish the results of this study, but we will not be asking for any information in the study that could be used to identify your child.

To keep this information safe, the results of the questionnaires will be kept on a secure server at the University of Michigan. The data from the Fitbit Charges will be kept on a secure software website called Fitabase and the data logged each day will use a number instead of any personal information.

To protect confidentiality, your child's real name will not be used. The researchers plan to keep this study data for two years at which time it will be destroyed. There are some reasons why people other than the researchers may need to see information your child provided. This includes organizations responsible for making sure that the research is done safely and properly, including the University of Michigan.

Participating in this study is completely voluntary. Even if you decide to allow your child to participate now, you may change your mind and stop at any time. If you decide to withdraw your child early, no further data will be collected. Your child will also be asked for consent. At this time they will be able to choose whether or not to take part in the study.

You will be given two copies of the consent form. Please keep one copy for yourself. Please return the second copy to your child's Physical Education teacher. Please feel free to contact me if you have any questions. My phone number is 734-904-7195 or you may contact me by email at heday@umich.edu

Thank you very much for your time,
Heidi Harris
1402 Washington Heights Ann Arbor, MI 48109
734-904-7195 heday@umich.edu

Please save this document

Consent to Participate in a Research Study

Title of the Project: Exercise Your Mind, Mind Your Motivation

Principal Investigator: Heidi Harris, PHD Student, University of Michigan

Faculty Advisor: Dr. Weiyun Chen, PHD, University of Michigan School of Kinesiology

Invitation to Participate in a Research Study

We invite your child to be part of a research study about developing strategies to improve a child's motivation and attention span in a classroom and physical activity setting. The study is funded by the University of Michigan, School of Kinesiology

Description of Your Involvement

You are being contacted because your child attends XXX School in the XXX Public Schools. We would like to work with your child to develop strategies to improve attention and motivation. The purpose of this study is to investigate the impact of a Physical Activity program focused on improving attention and motivation. We plan to ask children in 5th grade at Carpenter to participate in our research.

If you agree to allow your child to be a part of this study, your child will be placed into one of two groups. Both groups will take two sets of tests to measure motivation and attention.

- Both groups will be given a Fitbit Charge to wear for four weeks. This will collect the amount of physical activity, the Heart Rate and the amount of sleep your child gets. Your child will be asked to wear the Fitbit every day for five days, Monday through Friday. But not when it might get really wet, like swimming. It is ok to take it off at any time. You may also give it back to us if your child does not want to wear it. If it gets lost or stolen we will not charge you or your child.
- One group will take part in Physical Activities Engaging the Brain (PAEB). The PAEB are a series of six minute low to moderate physical activities and physical movements that are targeted to stimulate the brain. These are very low intensity activities. If your child is in this group they will do these activities each day in class for four weeks.

Benefits of Participation

Although your child may not benefit directly from being in this study, they will probably enjoy the videos and the exercise.

Risks and Discomforts of Participation

The researchers have taken steps to minimize the risks of this study. In order to avoid any the researchers will give each child a number instead of using their name. Some other risks, even when the researchers are careful to avoid them, may be present.

Compensation for Participation

There will be no financial compensation.

Confidentiality

We plan to publish the results of this study, but we will not be asking for any information in the study that could be used to identify your child.

Storage and Future Use of Data

To keep this information safe, the results of the questionnaires will be kept on a secure server at the University of Michigan. The data from the Fitbit Charges will be kept on a secure software website called Fitabase and the data logged each day will use a number instead of any personal information. To protect confidentiality, your child's real name will not be used. The researchers plan to keep this study data for two years at which time it will be destroyed. There are some reasons why people other than the researchers may need to see information your child provided. This includes organizations responsible for making sure that the research is done safely and properly, including the University of Michigan.

Voluntary Nature of the Study

Participating in this study is completely voluntary. Even if you decide to allow your child to participate now, you may change your mind and stop at any time. If you decide to withdraw your child early, no further data will be collected. Your child will also be asked for consent. At this time they will be able to choose whether or not to take part in the study.

Contact Information for the Study Team

Your child's Physical Education teacher will be collecting the consent forms, however please feel free to contact me if you have any further questions regarding this matter. My phone number is 734-904-7195 or you may contact me by email at heday@umich.edu

Thank you very much for your consideration and time,

Heidi Harris, PI heday@umich.edu
1402 Washington Heights
Ann Arbor, MI 48109
734-904-7195

Dr. Weiyun Chen, PHD chenwy@umich.edu
1402 Washington Heights
Ann Arbor, MI 48109
734-615-0376

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions or discuss any concerns about this study with someone other than the researcher(s), please contact the:

University of Michigan Health Sciences and Behavioral Sciences Institutional Review Board
2800 Plymouth Road
Building 520, Room 1169
Ann Arbor, MI 48109-2800
Phone: (734) 936-0933 or toll free, (866) 936-0933 Email: irbhsbs@umich.edu

Consent

Exercise Your Mind. Mind Your Motivation

Please note that you have been given two consent forms. The first is for you to keep. The second should be given to your child's physical education teacher.

By signing below you are agreeing to allow your child to take part in the study. Remember your child can opt out at any time, or choose not to answer some or all of the questions even if they had previously agreed to do so.

Consent

By signing this document, you are agreeing to allow your child__________________________ to be in the study. We will give you a copy of this document for your records. We will keep one copy with the study records. Be sure that we have answered any questions you have about the study and that you understand what you are being asked to do. You may contact the researcher if you think of a question later.

I agree to allow my child to participate in the study.

____

Printed Parent Name

____

Parent Signature   Date

Consent to Participate in a Research Study

Title of the Project: Exercise Your Mind, Mind Your Motivation

Principal Investigator: Heidi Harris, PHD Student, University of Michigan

Faculty Advisor: Dr. Weiyun Chen, PHD, University of Michigan School of Kinesiology

Invitation to Participate in a Research Study

We invite your child to be part of a research study about developing strategies to improve a child's motivation and attention span in a classroom and physical activity setting. The study is funded by the University of Michigan, School of Kinesiology

Description of Your Involvement

You are being contacted because your child attends Allen Elementary School in the Ann Arbor Public Schools. We would like to work with your child to develop strategies to improve attention and motivation. The purpose of this study is to investigate the impact of a Physical Activity program focused on improving attention and intrinsic motivation. We plan to ask children in 5th in the Ann Arbor Public Schools to participate in our research.

If you agree to allow your child to be a part of this study, your child will be asked to take two sets of tests which measure motivation and attention. The first test is meant to look at how your child feels about physical activity. The second will look at how well they are able to pay attention and to focus. Together the tests take about 15 minutes and they will be given during your child's physical education class. Your child will be given a wrist band with a number on it that says "University of Michigan: School of Kinesiology" on it. They can store this band in their desk. After the study is over they will get to keep the band. The physical education teacher will also be given the number in case they lose their wrist band.

Benefits of Participation

Although your child may not benefit directly from being in this study, it may help researchers understand what helps to keep kids physically active. It will also help us begin to see if there is a link between physical activity and a child's ability to pay attention in class.

Risks and Discomforts of Participation

The researchers have taken steps to minimize the risks of this study. In order to avoid any the researchers will give each child a number instead of using their name.

Compensation for Participation

There will be no financial compensation.

Confidentiality

We plan to publish the results of this study, but we will not be asking for any information in the study that could be used to identify your child.

Storage and Future Use of Data

To keep this information safe, the results of the questionnaires will be kept on a secure server at the University of Michigan. The researchers plan to keep this study data for two years at which time it will be destroyed. There are some reasons why people other than the researchers may need to see information your child provided as part of the study. This includes organizations responsible for making sure that the research is done safely and properly, including the University of Michigan.

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Contact Information for the Study Team

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Thank you very much for your consideration and time,

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1402 Washington Heights
Ann Arbor, MI 48109
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Dr. Weiyun Chen, PHD chenwy@umich.edu
1402 Washington Heights
Ann Arbor, MI 48109
734-615-0376

Contact Information for Questions about Your Rights as a Research Participant

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University of Michigan Health Sciences and Behavioral Sciences Institutional Review Board
2800 Plymouth Road
Building 520, Room 1169
Ann Arbor, MI 48109-2800
Phone: (734) 936-0933 or toll free, (866) 936-0933 Email: irbhsbs@umich.edu

Consent

Exercise Your Mind. Mind Your Motivation

Please note that you have been given two consent forms. The first is for you to keep. The second should be given to your child's physical education teacher.

By signing below you are agreeing to allow your child to take part in the study. Remember your child can opt out at any time, or choose not to answer some or all of the questions even if they had previously agreed to do so.

Consent

By signing this document, you are agreeing to allow your child__________________________ to be in the study. We will give you a copy of this document for your records. We will keep one copy with the study records. Be sure that we have answered any questions you have about the study and that you understand what you are being asked to do. You may contact the researcher if you think of a question later.

I agree to allow my child to participate in the study.

____

Printed Parent Name

____

Parent Signature Date

Appendix D

Child Intervention Assent Script

Exercise Your Mind. Mind Your Motivation

I am doing a study about exercise and if it helps you with your school work. Everyone will do some exercises in class or in the gym. I want to ask you some questions about how you feel about exercising. Even though your parents said it is OK for you to do this you can still say no. You can also skip any question you do not want to answer. If you change your mind later just tell your teacher you do not want to do this anymore. You will also wear a Fitbit on your wrist for 4 weeks to keep track of how far you walk or run. No one will be mad at you if the Fitbit is lost or broken.Do you want to answer some questions?

I agree to participate in the study.

____
Print Your Name

____
Sign Here Date

Child Comparison Assent Script

Exercise Your Mind. Mind Your Motivation

I am working on a study that looks at how exercise affects how you do in school. I would like to ask you some questions about how you feel about exercising. I would also like to see how well you pay attention. Even though your parents said it is okay to do this you can still choose to answer some of the questions or to just say no. Are you willing to answer the questions?

I agree to participate in the study.

____
Print your name

____
Sign Here Date

Appendix E

Demographics of Local Schools by Race and SES status (SDSS, 2014).

	Total # Students	Total number disadvantaged (% disadvantaged*)	Percent African American (% disadvantaged)	Percent Asian (% disadvantaged)	Percent Hispanic/ Latino (% disadvantaged)	Percent White (% disadvantaged)	Percent two or more races (% disadvantaged)
School 1	248	120 (**48.39%**)	18.55% (12.5%)	5.24% (2.02%)	19.76% (15.73%)	**43.95% (10.89%)**	**12.55%** (7.26%)
Fitbit School	**394**	**169 (42.89%)**	**30.71% (20%)**	**10.66% (4.57%)**	**7.11% (4.06%)**	**36.8% (8.88%)**	**14.47% (5.33%)**
Comparison School	**389**	**134** (34.45%)	18.25% **(14.14%)**	9.51% **(6.43%)**	**5.91% (2.83%)**	53.47% (14.14%)	12.34% (4.11%)
School 4	334	107 (32.04%)	**20.06%** (13.77%)	**10.18%** (1.85%)	12.28% (5.69%)	44.91% (5.99%)	12.57% **(4.79%)**

*Disadvantaged is categorized by groups who receive free or reduced lunch

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