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The Effect of Physical Activity on Youths' Cognitive, Academic, and Behavioral Outcomes: A Meta-Analysis of Single Case Design Studies

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The Effect of Physical Activity on Youths' Cognitive, Academic, and Behavioral Outcomes:

A Meta-Analysis of Single Case Design Studies

by

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Abstract

A third of youth in the United States are currently classified as overweight, which is impacted by the low rates of youth that meet daily physical activity recommendations. Engaging in physical activity contributes to healthy body weight and physical fitness, both of which have positive health consequences. Participating in physical activity not only aids in positive health outcomes, but research indicates that it also has a positive relationship with and effect on youths' cognitive, academic, and behavioral outcomes. The majority of researchers conducting meta-analyses examining the effect of physical activity on youths' cognitive, academic, and behavioral outcomes have excluded single-case design research from the data analyses. Excluding these types of designs from syntheses of the research may create an inaccurate account of the effect of physical activity on youths' cognitive, academic, and behavioral outcomes. The current study addressed these issues by conducting a meta-analysis of single-case design studies over approximately the past 50 years to add to the current understanding of the effect of physical activity on youths' cognitive, academic, and behavioral outcomes. Additionally, moderator analyses were conducted on numerous participant, intervention, and study characteristics that were deemed important, as indicated in the literature review. The effect size of physical activity on youths' academic and behavioral outcomes was determined by utilizing hierarchical linear modeling of the included 81 time series from 15 single-case design studies. There were not enough data to calculate the effect size on youths' cognitive outcomes. Large effect sizes were found that indicate physical activity has an effect on increasing youths' desirable behaviors (e.g.on task behavior and social skills) and decreasing youths' undesirable behaviors (e.g. self

stimulation, self-injurious behaviors, and off task behavior; ES = 1.83), as well as, increasing work completion, (ES = 2.01). No moderating effects were found other than the type of single case design moderated the effect on youths' behavioral outcomes. The current study is important for decision makers in schools when deciding whether to increase or decrease particular students' time spent in physical activity. Additionally, the results of the study are pertinent to other practitioners who work with youth, parents, and for youth themselves so that they can utilize physical activity interventions to help with appropriate behaviors and work completion.

Chapter I: Introduction

Statement of the Problem

The rate of childhood obesity has tripled since the 1980s (National Center for Chronic Disease Prevention and Health Promotion, 2011). More than a third of the youth in the United States between 2 and 19 years of age can be classified as overweight, approximately 15% are classified as obese, and approximately 11% are classified as severely obese (Ogden, Carroll, & Flegal, 2008). A contributing factor to obesity in the United States is inadequate levels of physical activity (Mahar et al., 2006). The recommended amount of physical activity for youth is 60 minutes daily of moderate to vigorous physical activity (US Department of Health and Human Services [USDHHS], 2005). Yet, researchers found that slightly less than 50% of children and only 8% of adolescents meet this daily goal (Troiano et al., 2008). Research results indicate that obesity has a stronger relationship with physical inactivity than with high rates of food intake (Ogden et al., 2008). Physical inactivity is also a public health concern, considering the inverse relationship between disease (including obesity) and physical activity. For example, researchers have found a positive relationship between physical inactivity and increased risk for cardiovascular disease, stroke, hypertension, type-2 diabetes, osteoporosis, colon cancer, breast cancer, anxiety, and depression (Reed et al., 2010).

One place where physical activity has decreased is at school. There has been increased accountability for the administration of schools to help students meet rigorous academic standards (Chomitz et al., 2009). This has caused many school administrators to take a number of resources away from physical education (PE) to increase the focus on academics. Renter et al.

(2006) found that 14% of school districts decreased time students spent in PE since 2001, when the federal government enacted the No Child Left Behind (NCLB) act. The purpose of the decreased time spent in PE was to allow for more direct math and English instruction (Renter et al., 2006). Lowry et al. (2004) found that in 1991, approximately 42% of high school students received daily PE, whereas in 2003, only 28% of high school students received daily PE. Yet, researchers have come to a consensus that time spent in PE classes, away from academic classes, does not negatively impact academics (Tomporowski, Davis, Miller, & Naglieri, 2008; Tomporowski, 2003). In fact, researchers conducting large-scale correlational studies have found a strong positive relationship between the time spent in physical activity or in PE and academic behaviors and achievement (Dwyer, Coonan, Leitch, Hetzel, & Baghurst, 1983; Grissom, 2005). Furthermore, results of experimental research have indicated a positive relationship between engaging in physical activity and youths' cognitive, academic, and behavioral outcomes (Castelli, Hillman, Buck, & Erwin, 2007; Hillman, Castelli, & Buck, 2005). Although the health benefits of physical activity are well-known, and research has demonstrated a positive relationship between physical activity and cognitive, academic, and behavioral outcomes among youth, additional research is needed in this area.

A number of reviews in the extant literature indicate that positive relationships or significant positive effects exist between physical activity and cognitive outcomes (Best, 2010; Fedewa & Ahn, 2011; Gapin, Lappan, & Etnier, 2011; Sibley & Etnier, 2003; Tomporowski, 2003; Tomporowski et al., 2008), academic outcomes (Erwin, Fedewa, Beighle, & Ahn, 2012, Fedewa & Ahn, 2011; Strong et al., 2005; Tomporowski et al., 2008; Tomporowski, 2003) and behavioral outcomes (Allison, Faith, & Franklin, 1995; Gapin et al., 2011; Sowa & Meulenbroek, 2012; Tomporowski, 2003).

Physical Activity and Cognitive, Academic, and Behavioral Outcomes

A significant body of research has presented the cognitive, academic, and behavioral outcomes associated with physical activity intervention, and a number of authors have provided narrative and quantitative reviews summarizing this body of research. In the following sections, this research will be reviewed.

Physical activity on youths' cognitive outcomes. Sibley and Etnier (2003) and Fedewa and Ahn (2011) conducted quantitative reviews examining the effects of physical activity on childrens' cognition (Fedewa & Ahn, 2011; Sibley & Etnier, 2003). In Sibley and Etnier's (2003) review, the overall effect size (ES) of physical activity on youths' cognitive outcomes for the included peer-reviewed experimental studies ($N = 9$) from 1954-2000 was .32. Fedewa and Ahn (2011) examined the overall ES of physical activity on youths' intellectual quotient (IQ), which was calculated from 19 ESs located in 59 studies from 1947-2009. The results were significant with a moderate to high ES of .39 (Fedewa & Ahn 2011). These reviews were well designed in terms of their search methods and the authors conducted a comprehensive search across a large period of time. The findings were similar, demonstrating moderate to high effect sizes for the effects of physical activity on cognitive outcomes among youth.

Physical activity on youths' academic achievement. In terms of the effect of physical activity on academic achievement, there have been two quantitative reviews (Erwin et al., 2012; Fedewa & Ahn, 2011). Erwin et al. (2012) examined the effect of classroom-based physical activity on academic outcomes, and included studies from 1990-2010. The researchers found only four classroom-based physical activity interventions and calculated a mean effect size of .67. In another recent meta-analysis, Fedewa and Ahn (2011) examined the effects of physical activity on youths' academic outcomes, including 59 studies between 1946 and 2009 for

analysis. The highest ES of all outcomes analyzed was found for math achievement at 0.44, the second outcome was a cognitive outcome, the third outcome was reading achievement at .36, followed by total achievement at .27, grade point average at .24, and spelling/vocabulary at .22. The results from these well-designed meta-analyses indicate that physical activity in the classroom and in other settings have a moderate to large effect on academic achievement, with varying ranges of effects for different measures of academic achievement.

Physical activity on youths' behavioral outcomes. There have also been two quantitative reviews regarding the effects of physical activity on the behavior of children (Allison, Faith, & Franklin, 1995; Sowa & Meulenbroek, 2012). Sowa and Meulenbroek (2012) conducted a meta-analysis of studies from 1991-2011, specifically analyzing the effects of physical activity interventions on the core symptoms of Autism Spectrum Disorder (ASD). The researchers found 16 studies that matched their criteria and found that physical activity interventions conducted with an individual child or group-based intervention had sizable effects on social skills. Improvement rates as a percentage was the metric utilized. Results indicated that improvement rates of interventions administered to an individual child were 71.43% and improvement rates for group-based intervention were 26.37% (Sowa & Meulenbroek, 2012). Allison et al. (1995) examined the acute effects of physical activity on disruptive behaviors (e.g., aggression, self-injury, talking out, etc.). The researchers included 16 studies conducted from 1972-1994 in the review. This was one of the few studies that included both group and single-case designs in their review; however, the analyses combined studies conducted with youth and adults together. The results of these studies indicated that 12 of the group studies resulted in positive outcomes with a weighted mean ES of .33. In addition, 22 of 26 single-case studies resulted in positive outcomes (mean ES = 1.99); 15 of these were studies conducted with youth,

while the other studies were conducted with adults. This is the only review located by the researcher of this project that included single-case design studies using separate statistical methods pertinent to the inclusion of single-case designs. Sowa and Meulenbroek (2012) included three single-case design studies out of a total of 16 studies that met the inclusion criteria for their meta-analysis. Sowa and Meulenbroek (2012), however, did not conduct statistical analyses that separated the single-case design studies from the group-design studies. Rather they combined all design types together for the analyses. Although numerous quantitative reviews were conducted concerning the effects of physical activity on cognitive, academic, or behavioral outcomes, minimal emphasis was placed on including single-case design studies.

In summary, the researchers who conducted quantitative reviews that included youths' behavioral outcomes focused on youth with a specific clinical diagnosis or disruptive behaviors and found a moderate to large effect on behavioral outcomes. The synthesis of single-case design studies included in Allison et al. (1995), who examined the effect of physical activity on the disruptive behavior of youth, indicated a very large effect size. Taken together, this research demonstrates the positive effects of physical activity on cognitive, academic, and behavioral outcomes of youth, and that more synthesis of the research is warranted, and that such a synthesis should include single-case design studies to provide a full account of the effect of physical activity on youths' outcomes. This full account will inform researchers and policy makers of which physical activity-related policies may best support childrens' cognitive, academic, and behavioral performance (Mahar et al., 2006).

Acute Versus Chronic Effects of Physical Activity

In reference to studying the effects of physical activity, there are two types of effects—chronic and acute—which are important to understanding research in this area. Chronic effects

are those resulting from multiple bouts of physical activity over time (Tomporowski, 2011). In contrast, acute effects are the immediate effects of a single bout of exercise on outcomes (Tomporowski, 2011). Although it is important to establish a link between physical activity and both chronic and acute effects of exercise, there are several reasons why it is particularly important for researchers to explore acute effects. First, when trying to understand the relationship between physical activity and cognitive, academic, and behavioral outcomes, it is important to initially establish if an immediate effect can be expected. To date, this question has not been answered clearly in the literature. From a practical standpoint, the demonstration of immediate effects could help encourage schools to incorporate physical activity during the day because students could experience an immediate "pay-off" from engaging in physical activity. In addition, this may help address the concern that spending time in physical activity takes away valuable time from learning academic content. Also, given that youth are only in school for a portion of the day, there are resource constraints within schools, making it difficult to implement interventions over a lengthy period of time, which would ultimately demonstrate the chronic effects on a student's functioning. However, in contrast, educators in schools do have access to students each day and it is plausible that they could influence student outcomes through the acute impact of physical activity. Another important reason to study the acute effects of exercise is that it is feasible for educators to include short bouts of physical activity throughout the day, rather than adding additional periods of physical education.

Single-Case Design Studies

It is often not feasible for educators to conduct large experimental design studies, but frequently they see the effect of implementing a particular intervention for a single student. To determine the reliability of these interventions, educators could capture these data scientifically

through conducting single-case design studies. Single-case designs (SCDs) have gained popularity within education, as they are particularly useful in this field (Zhan & Ottenbacher, 2001). The What Works Clearinghouse (http://ies.ed.gov/ncee/wwc/), which is often considered in determining which educational interventions are efficacious, includes single-case studies as acceptable research designs for determining efficacy. Zhan and Ottenabacher (2001) asserted that a decision made about one's education based on research conducted on many participants, as is done in group-design studies, may cause problems when those findings are applied to individual students. In addition, many studies conducted with youth with disabilities are conducted utilizing single-case designs because it is harder to have large numbers of participants when studying low-incidence populations (Parker, Vannest, & Brown, 2009). Another advantage of SCDs is that they allow for close examination of an intervention's immediate effects, which is important in the context of the current study.

One concern that is often raised with regard to single-case design studies is that they are not viewed as reliable because their external validity is low. One way that this concern can be addressed is by integrating the findings of multiple single-case design studies through meta-analysis techniques (Riley-Tillman & Burns, 2009). Although the importance of meta-analysis with SCD is important, many meta-analyses only include studies with control and treatment groups. This is true in the previous review of studies in which the researchers examined the effects of physical activity on cognitive, academic, and behavioral outcomes. Specifically, the researchers for only one meta-analysis included SCDs in their analyses (Allison et al., 1995), whereas other researchers included a few, but did not use separate statistical methods (Sowa & Meulenbroek, 2012). The methodology exists for including SCDs in meta-analyses (Van den Noortgate & Onghena, 2008), and it is important to be able to synthesize single-case design

studies to be able to further generalize their results. Also it is important for researchers to continue to synthesize findings from individual studies through meta-analyses so that others can easily determine the "big ideas" or conclusions from a body of research (Glass, 1976). Conducting a meta-analysis with SCD allows for effect sizes of many different studies to be combined to determine the overall effect that physical activity has on cognitive, academic, and behavioral outcomes in youth. Furthermore, conducting a meta-analysis provides a format for examining important variables that may moderate the effects of these interventions. For example, this could allow researchers to determine that a short bout of physical activity increases the processing speed of a child who is between 5 and 8 years of age, but does not have the same outcome for children between 8 and 11 years of age.

Purpose of the Present Study

The first purpose of this study was to examine the acute effects of physical activity on cognitive, academic, and behavioral outcomes of youth by conducting a quantitative synthesis analyzing the findings of single-case design studies. Due to the increased use of single-case designs in the past few decades (Scruggs & Mastropieri, 1998) and the acceptance of their results to determine evidence-based interventions, it is important to include their results when conducting meta-analyses. Otherwise, this could lead to an inaccurate representation of the effect size of the intervention. Although research on the effects of physical activity on cognitive, academic, and behavioral outcomes has been summarized through meta-analyses; all but two of these reviews excluded single-case designs. No meta-analyses have included SCDs when looking at academic or cognitive outcomes. In addition, the only meta-analysis that included SCD as a separate category was conducted over 20 years ago (Allison et al., 1995). Findings from single-case design studies are applicable for practitioners, as the nature of the study design lends itself

to developing appropriate individualized or small group physical activity interventions. The addition of a meta-analysis of single-case designs is important for adding, comparing, and contrasting with findings from previous quantitative reviews conducted mainly using group-design studies. In addition, this study was the first meta-analysis to analyze all three outcome areas (cognitive, academic, behavior) within one review, which is useful, due to the importance of these three outcome areas for educators and youth.

The second purpose of the study was to identify what moderators are likely to influence the effectiveness of physical activity on youth's cognitive, academic, and behavioral outcomes. It is important to not only know the overall effects of physical activity on outcomes, but also for whom and under what conditions this type of intervention is most likely to be effective. Based on the review of the literature, several moderator variables of interest have been found (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). Moderator variables that were analyzed for the study were categorized into three areas: (a) participant characteristics (i.e., grade range, age range, gender, specific disabilities, cognitive status, initial physical fitness level, race/ethnicity, and socio-economic status); (b) intervention characteristics (i.e., acute bouts of physical activity duration, intervention intensity, intervention agent or who delivered the intervention, type of physical activity, location where the intervention is implemented, and the unit of participants, whether in a group or individual); and (c) study characteristics (i.e., published/unpublished, outcome type measured, the type of single-case design, study country, specific measures, and how many data points are included in the case). The results of moderator analyses have been mixed in the previous quantitative reviews (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). Some reviews showed moderating effects for certain variables (Fedewa & Ahn, 2011; Sibley and Etnier, 2003) whereas different results or

no effect were indicated in other reviews (Fedewa & Ahn, 2011; Erwin et al., 2012).

A brief detailing of variables that were found to moderate the effect of physical activity and youths' outcomes follows. The summary includes moderators that were found to have an effect in at least one of the existing literature reviews. (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). For the participant characteristics, researchers found moderating effects for grade range, age range, specific disabilities, cognitive status, and physical fitness level, whereas researchers did not analyze gender, race/ethnicity, or socioeconomic status (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). For the intervention characteristics, researchers found moderating effects for the type of physical activity and the unit of participants, whereas researchers did not analyze the location of the intervention or the intensity of the physical activity (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). For the study characteristics, researchers found moderating effects for the outcome type measured (e.g., IQ versus processing speed) (Fedewa & Ahn, 2011; Sibley & Etnier, 2003), whereas researchers did not analyze the specific measures used or the type of single-case design (Allison et al., 1995; Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). Additionally, researchers from previous reviews called for future researchers of intervention studies to include data on potential moderators when conducting and reporting their studies, so that moderating effects can be more readily understood (Fedewa & Ahn, 2011; Tomporowski, 2011). By understanding more fully the moderating effects, practitioners will have additional information to decide the specific components of a physical activity intervention (e.g., considering the desired outcome, what duration, what type of physical activity, and how intense), and for whom the intervention is most likely to work. With the steady decline in the amount of physical activity in schools and in youths' lives overall, it is

important to study if physical activity is important to youths' cognitive, academic, and behavioral functioning, and to know the moderating variables.

Research Questions

The present study addressed the following research questions:

1. On average, what is the effect size of physical activity interventions on youths' cognitive outcomes among SCD studies?

Researchers who conducted meta-analyses have reported a positive effect size, using mainly group designs, on youth's cognitive outcomes (Fedewa & Ahn, 2011; Sibley & Etnier, 2003). The effect size found in previous reviews ranged from .32 to .39 (Fedewa & Ahn, 2011; Sibley & Etnier, 2003). There were no reviews that included single-case designs in their analyses; however, given findings from studies using group designs, it was hypothesized that physical activity will positively affect interventions on youths' cognitive outcomes and that the effect size will be approximately the same (moderate) or larger. It was hypothesized that it may be even larger due to the notion that with single-case designs, researchers are better able to measure small changes over time than with group designs.

2. On average, what is the effect size of physical activity interventions on youths' academic outcomes among SCD studies?

Erwin et al. (2012) conducted a quantitative review and found an average effect size of .67 for classroom-based interventions on academic outcomes. Fedewa and Ahn (2011) conducted a meta-analysis and found effect sizes of .22 for English/language arts, .27 for overall academic outcomes, and .44 for math achievement. In sum, the effect sizes ranged from small to moderate. Therefore, it was hypothesized that physical activity has a small to moderate positive acute effect on academic outcomes.

3. On average, what is the effect size of physical activity interventions on youths' behavioral outcomes among SCD studies?

Allison et al. (1995) conducted a meta-analysis that included an analysis of single-case design studies' average treatment effect and found an effect size of 1.99 for behavioral outcomes. Other researchers who conducted meta-analyses, literature reviews, and individual studies found that acute bouts of physical activity reduce disruptive behaviors in youth with a variety of clinical disorders and without such diagnoses (Gapin et al., 2011; Ridgeway, Northup, Pellegrin, LaRue, & Hightshoe, 2003; Sowa & Meulenbroek, 2012; Tomporowski, 2003; Vail, 1989). Based on the literature, it was hypothesized that physical activity has a moderate to large positive acute effect on youths' behavioral outcomes.

4. What participant characteristics moderate the relationship between physical activity and cognitive, academic, or behavioral outcomes?

Specific child characteristics examined included the following: (a) grade range, (b) age range, (c) gender, (d) specific disabilities (diagnoses of clinical disabilities such as Autism Spectrum Disorder), (e) cognitive status (if participants were described as having typical or atypical cognitive functioning), (f) race/ethnicity, (g) socio-economic status, and (h) initial fitness level of the participant.

a. The moderating effect of grade range has been studied before (Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). In regards to cognitive outcomes, Fedewa and Ahn (2011) found the strongest effects for elementary-aged youth, but ESs for students in middle and high school were also significant. Sibley and Etnier (2003) found that all grade groups had ESs that were significant, but found the strongest effects for middle school students, followed by young elementary school-

age students, then older elementary and high school students. Based on research findings, it was hypothesized that grade range has a moderating effect on the relationship between physical activity and youths' cognitive outcomes. In regards to academic outcomes, Fedewa and Ahn (2011) combined the ESs of studies whose researchers examined cognitive outcomes and academic outcomes, and found the strongest effects for elementary-aged youth, but ESs were also significant for students in middle and high school. Erwin et al. (2012) found that grade level did not moderate the effect of physical activity on youths' academic outcomes. Due to the mixed findings, no a priori hypothesis was made concerning the moderating effect of grade range on the relationship between physical activity and youths' academic outcomes. Researchers have not analyzed the moderating effect of grade range as related to behavioral outcomes in youth. Therefore, no a priori hypothesis was made concerning the moderating effect of grade range on the relationship between physical activity and youths' behavioral outcomes.

b. Age range was not analyzed for youths' cognitive or academic outcomes, therefore no a priori hypothesis was made concerning the moderating effect of age range on the relationship between physical activity and youths' cognitive and academic outcomes. Allison et al. (1995) found no difference across age groups for single-case design studies examining youths' behavioral outcomes. Therefore, it was hypothesized that age group does moderate the effect on the relationship between physical activity and youths' behavioral outcomes.
c. Gender was not analyzed as a moderator for any of the variables of interest. Therefore, no a priori hypothesis was made concerning the moderating effect of

gender on the relationship between physical activity and youths' cognitive, academic, or behavioral outcomes.

d. Sibley and Etnier (2003) found no moderating effect of specific disabilities on youths' cognitive outcomes. Therefore, it was hypothesized that specific disabilities does not moderate the effect between physical activity and youths' cognitive outcomes. No moderator analyses on specific disabilities were conducted for academic outcomes; therefore, no a priori hypothesis was made regarding the moderating effect of specific disabilities on the relationship between physical activity and youths' academic outcomes. No moderator analyses on specific disabilities were made for youths' behavioral outcome, however, in post hoc observations, Allison et al. (1995) found that the four studies with the largest ESs from group-design studies all defined their participants as hyperactive. Therefore, it was hypothesized that specific disability moderates the relationship between physical activity and youths' behavioral outcomes.

e. Fedewa and Ahn (2011) found a moderating effect of youths' cognitive status, in that youth who were cognitively impaired versus youth with typical neurodevelopment had ESs that were twice as large for both cognitive and academic outcomes. Therefore, it was hypothesized that cognitive status has a moderating effect on the relationship between physical activity and youths' cognitive and academic outcomes. Allison et al. (1995) found that cognitive status did not have a moderating effect on youth's behavioral outcomes. Therefore, it was hypothesized that cognitive status does not moderate the relationship between physical activity and youths' behavioral outcomes.

f. Race/ethnicity and socioeconomic status were not analyzed for any of the variables of interest. Therefore, no a priori hypotheses were made concerning the moderating effect of race/ethnicity or socioeconomic status on the relationship between physical activity and youths' cognitive, academic, or behavioral outcomes.

g. Fedewa and Ahn (2011) found a moderating effect of youths' initial physical fitness level for cognitive outcomes, in that elite athletes had the largest effect, as compared to normal and physically disabled youth. Therefore, it was hypothesized that youths' initial physical fitness level moderates the relationship between physical activity and youths' cognitive outcomes.

h. Youths' initial level of physical fitness was not analyzed for youths' academic or behavioral outcomes. Therefore no a priori hypothesis was made concerning the moderating effect of youths' initial level of physical fitness on the relationship between physical activity and youths' academic and behavioral outcomes.

5. What intervention characteristics moderate the relationship between physical activity and cognitive, academic, or behavioral outcomes?

Specific intervention characteristics examined include the following: (a) the total duration, in hours, of the intervention, (b) intervention intensity, (c) intervention agent (who delivered the intervention), (d) physical activity type (running, cycling, etc.), (e) the location of the intervention, and (f) the unit of participants (group or individual).

a. The moderating effect of duration was not analyzed for cognitive outcomes. Therefore, no a priori hypothesis was made concerning the moderating effect of duration on the relationship between physical activity and youths' cognitive outcomes. Duration was not found to moderate the effect for youths' academic and

behavioral outcomes (Allison et al., 1995; Erwin et al., 2012). Therefore, it was hypothesized that duration does not moderate the effect concerning the relationship between physical activity and youths' academic and behavioral outcomes.

b. The moderating effect of intervention intensity level was not analyzed for any of the variables of interest. Therefore, no a priori hypothesis was made regarding the moderating effect of intervention intensity level, concerning the relationship between physical activity and youths' cognitive, academic, or behavioral outcomes.

c. Fedewa and Ahn (2011) found that the person who delivered the intervention (agent) did not moderate the effect on youths' cognitive outcomes. Therefore, it was hypothesized that the intervention agent does not moderate the effect concerning the relationship between physical activity and youths' cognitive outcomes. The moderating effect of intervention agent was not analyzed for youths' academic or behavioral outcomes. Therefore, no a priori hypothesis was made regarding the moderating effect of agent, concerning the relationship between physical activity and youths' academic and behavioral outcomes.

d. Fedewa and Ahn (2011) found that intervention type moderated the effect on youths' cognitive and academic outcomes. Specifically, aerobic physical activity resulted in a larger ES than perceptual motor training and physical education. Therefore, it was hypothesized that the type of physical activity moderates the effect concerning the relationship between physical activity and youths' cognitive and academic outcomes. The type of physical activity moderated the effect for youths' behavioral outcomes (Allison et al., 1995). Specifically, non-aerobic physical activity had a larger ES than physical activity. Therefore, it was hypothesized that the type of physical activity has

a moderating effect concerning the relationship between physical activity and youths' behavioral outcomes.

e. The location in which the intervention was implemented was not analyzed for any of the variables of interest. Therefore, no a priori hypothesis was made related to this moderator on any of youths' cognitive, academic, or behavioral outcomes.

f. The intervention unit was found to moderate the effect on youths' cognitive, academic, and behavioral outcomes. Specifically, for cognitive and academic outcomes, interventions conducted with small groups of youth had the largest effect, then medium groups, followed by large groups and whole classes (Fedewa & Ahn, 2011). Additionally, Fedewa and Ahn (2011) found mixed-gender groups to have more of an effect than single-gender groups for both cognitive and academic outcomes. For behavioral outcomes, Sowa and Meulenbroek (2012) found that interventions delivered to an individual versus a group of participants had a larger effect for youth with ASD on social outcomes. Therefore, it was hypothesized that intervention unit moderates the effect concerning the relationship between physical activity and youths' cognitive, academic, and behavioral outcomes.

6. What study characteristics moderate the relationship between physical activity and cognitive, academic, or behavioral outcomes?

Specific study characteristics examined include the following: (a) published/unpublished, (b) outcome type measured (e.g., behavioral, cognitive, and/or academic), (c) the type of single-case design utilized, (d) country in which the study was conducted, (e) specific measures used (e.g., Woodcock Johnson, Conners-Teacher and Parent Report, etc.), and (f) how many data points are included in the case.

a. Fedewa and Ahn (2011) found no moderating effect for publication status for youths' cognitive outcomes, however Sibley and Etnier (2003) found a moderating effect. Specifically, unpublished studies indicated a significantly larger effect than published studies (Sibley & Etnier, 2003). Due to the mixed findings, no a priori hypothesis was made regarding the moderating effect of publication status, concerning the relationship between physical activity and youths' cognitive outcomes. Fedewa and Ahn (2011) found no difference between published and unpublished studies for youth's academic outcomes. Therefore, it was hypothesized that publication status does not moderate the effect concerning the relationship between physical activity and youths' academic outcomes. Allison et al. (1995) found that unpublished studies had a significantly larger effect size than published studies for youths' behavioral outcomes. Therefore, it was hypothesized that publication status moderates the effect concerning the relationship between physical activity and youths' behavioral outcomes.
b. Sibley and Etnier (2003) found a moderating effect of the type of outcome measured used for youths' cognitive outcomes. Specifically, ESs were significant across a variety of types of cognitive outcomes, except memory, with IQ being the largest. Fedewa and Ahn (2011) also found IQ to have a large effect size. Therefore, it was hypothesized that the type of outcome measured will moderate the effect concerning the relationship between physical activity and youths' cognitive outcomes. Related to youths' academic outcomes, Fedewa and Ahn (2011) found a moderating effect for the types of outcome measures used. The researchers ranked ESs from highest to lowest, in the following order: math

achievement, reading achievement, total achievement, other, grade point average, spelling/vocabulary, and science. Therefore, it was hypothesized that the type of outcome measured will moderate the effect concerning the relationship between physical activity and youths' academic outcomes. The type of outcome measured was not analyzed for youths' behavioral outcomes. Therefore, no a priori hypothesis was made regarding the moderating effect of the type of outcome measured, concerning the relationship between physical activity and youths' behavioral outcomes.

c. The type of SCD used was not analyzed as a moderator for any of the variables of interest. Therefore, no a priori hypothesis was made regarding the moderating effect of the type of SCD used, concerning the relationship between physical activity and youths' cognitive, academic, and behavioral outcomes.

d. Fedewa and Ahn (2011) found no moderating effect regarding the country in which the study was conducted, concerning youths' cognitive outcomes. Therefore, no a priori hypothesis was made regarding the moderating effect of the study's country, concerning the relationship between physical activity and youths' cognitive outcomes. Fedewa and Ahn (2011) found no moderating effect regarding the country in which the study was conducted, concerning youths' academic outcomes. However, Erwin et al. (2012) found a moderating effect for youth's academic outcomes. Specifically studies conducted in Europe had a significantly larger ES than studies conducted in the U.S. Due to the mixed findings, no a priori hypothesis was made regarding the moderating effect of the study location, concerning the relationship between physical activity and youths'

academic outcomes. Study location was not analyzed as a moderator for youths' behavioral outcomes. Therefore, no a priori hypothesis was made regarding the moderating effect of study location, concerning the relationship between physical activity and youths' behavioral outcomes.

e. Researchers of the previous reviews did not analyze the moderating effect of specific measures for any of the variables of interest. Therefore, no a priori hypothesis was made regarding the moderating effect of specific measures used, concerning the relationship between physical activity and youths' cognitive, academic, and behavioral outcomes.

f. Researchers of the previous reviews did not analyze the amount of data points included in the study for any of the variables of interest. Therefore, no a priori hypothesis was made regarding the moderating effect of the amount of data points included in the study, concerning the relationship between physical activity and youths' cognitive, academic, and behavioral outcomes.

Definition of Key Terms

Academic outcomes. Academic outcomes are related to the level of performance an individual has on educational goals (Ward, Stoker, & Murray-Ward, 1996). Examples of measures of academic outcomes include grade-point averages, scores on standardized tests, and subject-specific grades (Carlson et al., 2008).

Acute effects of physical activity. The immediate effect of one bout of physical activity on outcomes measured (Tomporowski, 2011).

Behavioral outcomes. Behavior refers to any activity that living organisms can perform. As it relates to humans, this includes what we are able to do, what we think, and our feelings

(Skinner, 1974). Common problem behaviors in this body of literature include stereotypic behaviors, self-injury, aggression, and off-task verbal behaviors. Desirable behaviors may include on-task classroom behaviors, such as paying attention, writing when asked to write, and waiting quietly.

Chronic effects of physical activity. The effect of participating in many bouts of physical activity over time (e.g., days, weeks, months) on outcomes measured (Tomporowski, 2011).

Cognitive outcomes. The term cognitive means, "of or relating to cognition" (Mish, 2007, p.129). Cognition is a broad word for explaining many varying mental processes of acquiring and understanding information. Some examples of these processes include processing speed, short-term memory, visual-spatial reasoning, executive functioning, perceptual reasoning, and verbal ability. One measure of cognition is intelligence (Tomporowski, 2009).

Meta-analysis. This statistical method was first introduced by Glass (1976) as a quantitative approach to summarize results of studies. Glass (1976) defined it as "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p.3).

Moderators. "A qualitative (i.e., sex, race, class) or quantitative (i.e. level of reward) variable that affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable" (Baron & Kenny, 1986, p. 1174).

Physical activity. "Bodily movement produced by skeletal muscle that results in energy expenditure, including elective forms of activity, such as sport and exercise" (Kilpatrick, Hebert, & Bartholomew, 2005, p. 89).

Single-case design. This type of research design involves one or multiple treatments at multiple time points, using the individual or a group as their own control (Kazdin, 2011).

Youth. The term refers to individuals from 3-18 years of age.

Chapter II: Review of the Literature

In this chapter, background information concerning expectations and actual engagement in physical activity among youth, the association between physical fitness and cognitive and academic outcomes, and physical activity opportunities in schools will be reviewed. Then there is a discussion of the theories describing the effects of physical activity on children's cognitive, academic, and behavioral functioning. Next, a review ensues of the extant meta-analyses and literature reviews related to the effects of physical activity on these three domains of children's functioning. Finally, a discussion follows concerning the importance of single-case designs, integrating research findings through meta-analysis, and conducting meta-analyses of single-case design studies.

Physical Activity Among Youth

The positive impact of physical activity on health outcomes has been the focus of much research (Malina, Buchard, & Bar-or, 2004). However, the Centers for Disease Control and Prevention (CDC; US Department of Health and Human Services [USDHHS], 2008) stated that children are not meeting the USDHHS recommendation for participation in 60 minutes or more of moderate to vigorous physical activity per day. Troiano (2008) reported that only 42% of children and 8% of adolescents in the U.S. are meeting this goal. During the previous three decades, youth have become more sedentary (USDHHS, 2009). This sedentary lifestyle is a health concern, as researchers have found a relationship between physical inactivity and higher rates of childhood obesity (USDHHS, 2000). Children who are overweight or obese have an increased risk for diabetes, hypertension, coronary heart disease, osteoarthritis, and being obese

as an adult (Must et al., 1999). The obesity rates of children and adolescents in the US have significantly increased in the last 30 years (Hedley et al., 2004). The most recent CDC figures from the National Health and Nutrition Examination Survey (USDHHS, 2014) on obesity in youth gathered between 2011-2012 indicated the following concerning obesity in youth in the US: 8.4% of children aged 2 to 5 years, 17.7% of children aged 6 to 11 years, and 20.5% of adolescents aged 12 to 19 years are considered obese (Ogden, Carroll, Kit, & Flegal, 2014). Although research has shown that engaging in physical activity can have health benefits, the number of children meeting physical activity recommendations is low and obesity in childhood remains a key public health concern in the US.

Due to the increased rates of youth living sedentary lifestyles and engaging in less physical activity, researchers have examined the relationship between physical fitness levels of youth and both cognitive and academic outcomes. Most research results have indicated a positive association between physical fitness and cognitive and academic outcomes. Castelli, Hillman, Buck, and Erwin (2007) found that the aerobic ability of children was positively associated with academic achievement, whereas Body Mass Index (BMI), a measurement of healthy or unhealthy weight, was inversely related with achievement. Other studies results have shown a positive relationship between a youth's level of physical fitness and their academic achievement (California Department of Education, 2005; Shepard, LaVallee, Volle, LaBarre, & Beaucage, 1994; Shepard, Volle, Lavallee, LaBarre, Jequier, Rajic, 1984). In addition, researchers have reported that being overweight during childhood is negatively associated with academic achievement (Datar, Sturm, & Magnabosco, 2004; Roberts, Freed, & McCarthy, 2010; Shore et al, 2008; Taras & Potts-Datman, 2005), cognition (Alonso-Alonso & Pascual-Leone, 2007; Campos, Sigulem, Moraes, Escrivao, & Fisberg, 1996; Li, 1995), and psychosocial outcomes

(Falkner et al., 2001). However, Gunstadt et al. (2008) found no relation between elevated BMI and performance on a battery of neuropsychological tests. The results of much of the research examining the relationship between fitness levels and/or obesity levels of youth and both cognitive and academic outcomes for these youth indicate that fitness is positively associated with achievement and cognition (California Department of Education, 2005; Castelli, Hillman, Buck, and Erwin, 2007; Shepard, LaVallee, Volle, LaBarre, & Beaucage, 1994; Shepard, Volle, Lavallee, LaBarre, Jequier, Rajic, 1984), whereas being overweight has a negative relationship with these same outcomes (Alonso-Alonso & Pascual-Leone, 2007; Campos, Sigulem, Moraes, Escrivao, & Fisberg, 1996; Castelli, Hillman, Buck, and Erwin, 2007; Datar, Sturm, & Magnabosco, 2004; Li, 1995; Roberts, Freed, & McCarthy, 2010; Shore et al, 2008; Taras & Potts-Datman, 2005).

Physical Activity in Schools

Approximately 95% of all youth in the US, or 56 million youth, spend approximately 30 hours per week in school (USDHSS, 2010). School settings provide an environment where the CDC recommendation for daily physical activity levels could be met (USDHSS, 2010). In fact, the school setting is an ideal place for children to engage in the recommended amount of physical activity, as most opportunities for children to participate in moderate to vigorous physical activity occurs during the school day (Guinhouya, Lemdani, Vilhelm, & Hubert, 2009). There are several ways in which youth participate in physical activity in schools, including PE classes, classroom activities, and recess. Recent evidence indicates that throughout the US, there has been a decline in the amount of time children spend in PE (Coe, Pivarnik, Womack, Reeves, & Malina, 2006). Some suggest this decline may be related to the emphasis on national literacy and numeracy assessments (Chomitz et al., 2009).

The most recent School Health Policies and Programs Study reported that few schools have daily physical education in all grades for the entire school year (USDHHS, 2006). Specifically, 3.8% of elementary schools, 7.9% of middle schools, and 2.1% of all high schools have daily PE for the whole school year (USDHHS, 2006). This is concerning, given that there is evidence that not only is PE important to children's health (Shepard, 1997; Sallis, Patterson, Buone, & Nader, 1988), but also to other key school outcomes. For example, strong positive relationships were found between the amount of physical activity or participation in PE and appropriate school behavior and academic achievement (Carlson et al., 2008; Grissom, 2005). The CDC (USDHHS, 2010) conducted a literature review to assess the impact of school-based physical activity on the academic performance of youth. The literature review included 14 studies, the researchers for which utilized PE as a part of the physical activity intervention, as either PE as usual compared to no PE or enhanced PE compared to regular. The CDC suggested that the literature shows that time spent in PE has no relationship with academic achievement. The results of this review indicated that more time in PE does not have a negative impact on academic achievement.

There are opportunities to incorporate physical activity throughout the school day other than during PE classes, and there are even ways to embed academic material into the physical activities, as well. One such opportunity is through in-class physical activity. There have been a small number of studies, the researchers for which were looking at the effects of in-class physical activity on physical activity level, behavior, and learning outcomes (Donnelly et al., 2009; Ericsson, 2008; Erwin, Fedewa, Beighle, & Ahn, 2012; Williams, 1991). Results of studies for which the researchers investigated the effects of in-class physical activity interventions on behavioral outcomes have all shown positive effects on youths' time on task during academic

work (Baker, 2005; Grieco, Jowers, & Bartholomew, 2009; Mahar et al., 2006). Erwin, Fedewa, Beighle, and Ahn (2012) conducted a quantitative review of all the in-class physical activity interventions on the academic achievement of youth and found a large effect size of .67. The CDC also reviewed the effects of classroom-based physical activity on youths' outcomes (USDHHS, 2010). They located nine articles for inclusion in the literature review and found that typically, the intervention included five to 20-minute physical activity breaks. Of the nine studies, eight were found to have positive associations between the in-class physical activity and cognitive, academic, and behavioral outcomes of the youth.

Another way youth have opportunities for physical activity is through recess, which has been embedded in the educational system since its inception (Pellegrini & Bjorklund, 1997). Few researchers have found that recess positively impacts academic outcomes (Jarrett et al., 1998; Ridgeway, 2003). The literature review conducted by the CDC identified studies that examined the relationship between recess and the academic performance of children in elementary school (USDHHS, 2010). Six of these studies included an intervention, whereas the other two were correlational. All of the studies reviewed found at least one positive relationship among recess and measures of cognitive skills and academic behaviors. PE, in-class physical activity, and recess are important because they provide an opportunity to meet daily physical activity recommendations. In addition, research results have indicated that physical activity has the potential to have a positive effect on youths' cognitive, academic, and behavioral outcomes, which are all important outcomes in the school setting (Allison, Faith, & Franklin, 1995; Erwin et al., 2012; Fedewa and Ahn, 2011; Sibley and Etnier, 2003; Sowa & Meulenbroek, 2012).

Theories Concerning the Effects of Physical Activity

Different theories exist which explain the relationship between physical activity and its

effects on the cognitive and academic outcomes of children. There is a lack of theories regarding the relationship between physical activity and behavioral outcomes among youth. These three outcome domains are important to examine because they are important to children's school, social, and family functioning, and are predictors of children's later adult functioning.

Theories that exist that impact the relationship between physical activity and cognitive, academic, and behavioral outcomes can vary based on the type of effect of physical activity. Physical activity interventions are frequently defined as having either acute or chronic effects. Tomporowski, Lambourne, and Okumura (2011) provided definitions for these differing types of effects. Tomporowski et al. (2011) stated that studies that explore chronic effects of exercise examine the effects of many sessions of the physical activity on a particular outcome variable, such as cognition, academic achievement, or behavior. Researchers who focus on the acute effects of physical activity observe the immediate outcomes after one session of the physical activity. Best (2010) suggested that for the two types of effects—acute and chronic—the physiological pathways that may enhance cognitive functioning through physical activity differ for each type of effect. However, the researcher for the present study will review only explanatory theories related to the acute effects, as this represents the type of effect that the researcher will examine in the present study. The key theories that the researcher outlined to explain the effects of physical activity on cognitive, academic, and behavioral outcomes include physiological mechanisms, the inverted U hypothesis, and Tomporowski et al.'s (2011) model of mediators and moderators of the effect of physical activity on children's mental functioning.

Physiological explanations. Several physiological mechanisms have been hypothesized to explain how physical activity impacts brain function. These theories resulted from numerous studies, the results of which indicated that engaging in physical activity changes brain structures.

The proposed mechanisms include structural modifications in the central nervous system (CNS) and changes in brain neurotransmitters (Sibley & Etnier, 2003).

In terms of structural modifications in the CNS, one hypothesis is that engaging in physical activity produces neurotrophins, which are neurochemicals responsible for growing, keeping alive, and differentiating neurons throughout development, and are part of the process in dendritic branching (Ploughman, 2008*)*. This theory holds that physical activity increases these neurotrophins, including brain-derived neurotrophic factor, insulin-like growth factor, and basic fibroblast growth factor (Ploughman, 2008). Measuring the acute effects of physical activity shows that by engaging in one bout of physical activity, neurochemical changes occur immediately, which may positively impact cognitive performance.

Inverted U hypothesis. Arousal theories exist to explain the physical activity and cognition relation (Humphreys & Revelle, 1984). This theory is referred to as an inverted U hypothesis and has been examined in studies by measuring participants' physiological arousal, using heart rate, oxygen uptake, or other biological mechanisms. Results from studies indicated that as physical activity is manipulated, there are changes to these arousal levels (Lambourne & Tomporowski, 2010). Cognitive performance was found to improve as arousal levels increase; however, once arousal reaches the maximal levels of arousal, performance begins to decrease. This relationship can be visualized as the shape of an inverted U. This theory suggests that if an individual sustains physical activity at a moderate intensity, then cognitive performance remains high, but once an individual engages in vigorous activity, the cognitive performance then slopes downward over time (McMorris & Graydon, 2000). However, some researchers have questioned the universal validity of this model and posit that the relationship between physical activity

arousal and cognitive performance is moderated by a person's level of fitness, a hypothesis which needs further empirical investigation (Tomporowski 2003).

Tomporowski, Lambourne, and Okumura (2011) working model of mediators and moderators of the effect of physical activity on childrens' mental functioning. None of the theories discussed above encompass the various contextual and psychosocial factors that may play a role in the relationship between physical activity and children's cognition. To address this, Tomporowski, Lambourne, and Okumura (2011) proposed a model to explain the possible mediators and moderators that may relate to how physical activity impacts children's mental functioning (see Figure 1).

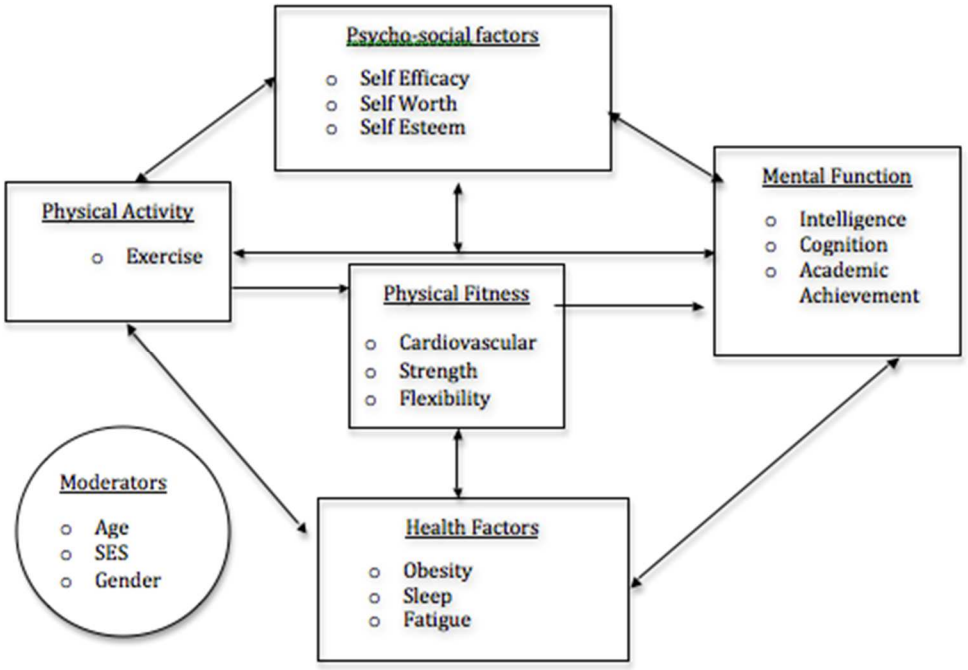

Figure 1. Tomporowski, Lambourne, & Okumura (2011) working model of possible mediators and moderators that could influence the relationship of physical activity on children's cognition and academic achievement. SES stands for socioeconomic status.

This model proposes that physical fitness may be a possible mediator between the effects of physical activity and cognitive function. These researchers proposed that a person's health status (e.g., weight, sleep status, and fatigue) could also serve as a mediator. This model also proposes that there are various psychosocial factors that may mediate the relationship between physical activity and cognition. Moderators in the model include age, socioeconomic status/culture, and gender, and are included to indicate that they may impact the strength of the relationship between physical activity and cognition in children.

Although this model has not yet been fully tested, several studies support aspects of this model. Regarding the hypothesized physical fitness mediators, the results of some studies have supported the claim that high levels of physical fitness may have a positive relationship with academic and cognitive outcomes (Blom, Alvarez, Zhang, & Kolbo, 2011; Castelli et al., 2007; Hillman et al., 2005). However, Tomporowski et al. (2011) reported that other aspects of fitness such as muscle strength, endurance, and flexibility have received far less attention.

In support of some psychosocial factors in the model, researchers have found evidence that girls' self-concept has been heightened by the experience of being successful in a physical activity (Dishman, Dunn, Sallis Vandenberg, & Pratt, 2009), as well as youths' self-efficacy (Bandura, 1994). However, it has yet to be determined if these variables mediate the relationship. Regarding self-esteem, Crosnoe and Muller's (2004) results indicated that a relationship existed between higher BMI and decreased academic performance, but only if the students in the school perceived that being obese was stigmatized.

Regarding health status moderators, the results of correlational studies have indicated the existence of a relationship between obesity and lower testing scores on measures of intelligence (Roberts et al., 2010; Yu, Han, Cao, & Guo, 2010) and on other measures of cognition (Li, Dai,

Jackson, & Zhang, 2008). Gunstadt et al. (2008), however, found no evidence of an inverse relationship between scores on tests of cognitive functioning and BMI. Results from other studies showed an inverse relationship between obesity and academic achievement (Datar, Sturm, & Magnabosco, 2004; Shore et al., 2008). Tomporowski et al. (2011) did not provide information regarding whether there is evidence suggesting that sleep quality/quantity or fatigue may have a mediating effect between physical activity and mental functioning. Tomporowski et al. (2011) posited that it is important for researchers to look at what impact these moderators and mediators have on the relationship between physical activity and cognition, intelligence, and academic achievement.

Effects of Physical Activity on Youths' Cognitive, Academic, and Behavioral Outcomes

In this section, there is a review of the literature concerning the effects of physical activity on youths' cognitive, academic, and behavioral outcomes. Included is a review of the existing quantitative and narrative literature reviews to provide a detailed account of the majority of extant group-designed studies on the acute effects of physical activity on the aforementioned outcomes.

Cognition. Researchers for two quantitative reviews examined the effects of physical activity on children's cognition (Fedewa & Ahn, 2011; Sibley & Etnier, 2003). Sibley & Etnier (2003) conducted a quantitative review and included 44 studies between the years 1954 and 2000, of which 17 were experimental. Of these 17, nine were peer-reviewed studies. These researchers included all English-language studies for which the researchers examined a relationship between physical activity and cognition or academic performance on elementary-aged youth (6 - 13 years). Search methods utilized included searching databases, specifically PsychInfo, ERIC, Medline, and Dissertation Abstracts. Keywords used were *physical activity,*

physical education, exercise, cognition, academic, achievement, intelligence, and *children*. Other search methods included reviewing references from important studies and reviews, as well as contacting lead researchers in the field to obtain additional studies. This review included studies that examined both the acute and chronic effects of physical activity. The researcher of the study calculated the effect sizes for each study and overall, using Hedge's *g* for physical activity on youths' cognitive outcomes. The overall effect size of physical activity on elementary-aged youths' cognitive outcomes for all the peer-reviewed studies was .32. Moderator analyses were conducted, but are reviewed in a later section that focuses on the outcomes of moderator analyses from the existing quantitative reviews.

Fedewa and Ahn (2011) found 59 studies published between 1947 and 2009, which included 195 effect sizes looking at the effects of physical activity on both cognition and academic achievement that met their criteria. Specific criteria studies needed to meet included the following: (a) examined the relationship between physical activity and youth's cognitive functioning, (b) youth between the ages of 3-18 years, (c) included statistical data to calculate ES, (d) data was only included once to avoid replication, and (e) studies were reported in English. To locate relevant studies, researchers used various keywords to search relevant databases, including, PyshcLit, PsychInfo, Dissertation Abstracts, MedLine, and ERIC. Key search terms were *physical activity, physical fitness, physical education, curricular activity, exercise, cognition, achievement, academic, intelligence, students*, and *children*. Other search methods included using key words to search general search engines (e.g., Google, Yahoo, etc.), as well as examining other studies resulting from searching literature reviews and ancestry searches. The researcher included studies in which researchers examined both the acute and chronic effects of physical activity in the meta-analysis. Since the researcher included different

study designs in the meta-analysis, there were different methods of calculating ESs. For studies with pretest-posttest control group designs, the researcher computed the standardized mean change for the treatment and control groups, whereas, if there was no comparison group, then the researcher calculated the standardized mean gain. If the study was a posttest control group design, then the researcher calculated the standardized mean difference. For studies that did not include means and standard deviations, the researcher calculated Hedge's g_i from *t* or *F* statistics. The researcher found the overall ES for IQ to be significant, with a moderate to high ES of .39. Both of these aforementioned quantitative reviews examining the effect of physical activity on the academic outcomes of youth found similarly sized effect sizes. Moderator analyses were conducted, but are summarized in a later section of the current study.

In addition to the quantitative reviews, researchers have conducted narrative reviews (Best, 2010; Gapin, Lappan, & Etnier 2011; Tomporowski, 2003), examining the effects of physical activity on childrens' cognition. These narrative reviews described the acute effects of physical activity on cognitive outcomes (Tomporowski, 2003), effects of physical activity on executive function in nonclinical samples (Best, 2010), and cognitive outcomes among youth with Attention-Deficit Hyperactivity Disorder (ADHD; Gapin et al., 2011). Although the authors of these reviews did not include a quantitative evaluation of findings across studies, overall the authors suggested that there is modest support for a positive relationship between physical activity and children's cognitive outcomes.

Tomporowski (2003) investigated children's response to the acute effects of physical activity, of which the review included only three studies, all experimental, in which cognitive outcomes were examined. The other studies included in the review involved academic achievement and behavioral outcomes. A synopsis of the three studies concerning cognitive

outcomes is relevant. Two of the three studies' findings indicated a positive acute effect of physical activity on processing speed (Caterino & Polak, 1999; Raviv & Low, 1990), whereas the results of the third study showed no effect of physical activity on short-term memory for boys with and without ADHD (Craft, 1983). The researcher labeled what the proposed study refers to as academic achievement outcomes, as cognitive outcomes, thus rendering the overall conclusions the researcher exerted not aligned with the definitions of cognition.

Best (2010) conducted a review which was specific to executive function, which is an umbrella term that encompasses the cognitive processes responsible for organizing and controlling goal-directed behavior (Banich, 2009). Best (2010) included experimental design studies that examined the chronic or acute effects of physical activity on executive functioning of youth without clinical disorders. There were seven studies examining the acute effects of physical activity that met the study's inclusion criteria. Best (2010) concluded that physical activity performed at a moderate to vigorous intensity is the most beneficial intensity level to enhance executive functioning. Specifically, Best (2010) found that aerobic activity enhances executive functioning; however, more complex physical activities (e.g., bimanual coordinative physical activities, group games) have a stronger impact, as compared to simpler activities (e.g., running on a treadmill).

Gapin et al. (2011) conducted a narrative review, in which they studied the effect of physical activity on cognitive outcomes in youth with ADHD. Gapin et al. (2011) included two studies, the researchers for which examined the effects of physical activity on children's cognition. Gapin and Etnier (2010a) studied the relationship between participating in chronic physical activity and cognitive outcomes in youth with ADHD, but the researcher for the present study will not review the results of that study herein. Medina et al. (2010) examined the acute

effects of high-intensity physical activity on the attention levels of boys diagnosed with ADHD. Pre and post data showed a significant increase in sustained attention and decreased impulsivity after acute bouts of high-intensity physical activity on a treadmill (Medina et al., 2010). The results of this study indicated that physical activity may be particularly beneficial for children diagnosed with ADHD and that moderate to vigorous physical activity had the largest impact on sustained attention, information processing, inhibition, and working memory. Among these four reviews of the literature, there was a relatively-large number of studies ($N = 32$), the researchers for which explored the link between physical activity and cognition, yet study differences (e.g., in the type of measures used, differences in type of physical activity, the type of research design, and participant characteristics, such as if they did or did not have a clinical diagnoses), thus making comparisons difficult and may underlie the inconsistent findings. The results of the studies investigating cognition indicated that acute effects of physical activity led to moderately-sized improvements in cognition; however, there were variable results, potentially due to the variations in design, participants, and intervention characteristics. Further research is needed, as the researcher for the present study found no replication of studies. However, what can be gleaned from a review of the literature is that researchers who conducted quantitative reviews (Sibley & Etnier, 2003; Fedewa & Ahn, 2011) found a similar moderately-sized ES for the impact of physical activity on IQ (i.e., .32 and .39, respectively). The fact that three of the five reviews in this area are narrative is a limitation, as no firm conclusions can be drawn from narrative reviews. The researchers of the reviews and meta-analyses agreed that there is a need to create a more thorough understanding of the relationship, causality, and moderators between physical activity and cognitive outcomes.

Academic achievement. The researchers for two quantitative literature reviews (Erwin, Fedewa, Beighle, & Ahn, 2012; Fedewa & Ahn, 2011) examined the relationship between physical activity and academic achievement among youth. Erwin et al. (2012) statistically analyzed studies that examined the effect of physical activity within a classroom on youth's academic outcomes. These researchers identified studies through various search methods. They searched databases, specifically Ovid, MEDLINE, PsychINFO, PubMed, and SPORTDiscus using the key search terms of *classroom*, *physical activity*, and *school*. Furthermore, footchasing methods were used by reviewing the references in key articles and published reviews. All articles were published between January 1990 and February 2010. Review inclusion criteria were as follows: (a) the participants were between 5-18 years of age, (b) physical activity was conducted in the classroom, (c) outcome measures were physical activity or learning behaviors, (d) studies were published between 1990 and 2010, and (e) enough data was given to calculate ESs. Review exclusion criteria included: (a) if the study only described the implementation or design only, (b) it was not published in English, and (c) if the classroom-based component was only one part of the physical activity intervention. The effect sizes for the meta-analysis were calculated as the difference between treatment and control group means in a pooled standard deviation unit. If descriptive statistics were not provided and *F* or *t* statistics were provided, then a formula by Lipsey and Wilson (2001) was utilized. Through these methods, four studies were included in their analysis of classroom-based physical activity intervention's effects on academic outcomes, with a mean effect size of .67. The researchers for the included studies examined either acute or chronic effects of physical activity. Moderator analyses were conducted, but are reviewed in a later section of the current study.

Fedewa and Ahn (2011) conducted a meta-analysis in which they examined the effects of physical activity on childrens' academic and cognitive outcomes. The researchers reviewed 59 studies that met their inclusion criteria, finding 195 ESs and 155 of these ESs included achievement measures. They broke their analyses down by academic subject area. The highest ES of all outcomes analyzed was found for math achievement at 0.44, second was reading achievement at .36, followed by total achievement .27, grade point average .24, and English/language art (spelling & vocabulary) .22. Fedewa and Ahn (2011) also conducted moderator analyses, which is detailed in a later section of the present study.

In addition to the two quantitative reviews, there were two reviews using other methods. First, there was an expert panel review concerning the effects of physical activity on academic achievement of youth (Strong et al., 2005) and a narrative review on the acute effects of physical activity (Tomporowski, 2003). The authors of these reviews suggested that the literature indicates academic achievement is not negatively impacted by time spent engaged in physical activity versus academic activities, and there are some immediate benefits. This is posited to be the most salient finding related to the study of the effect of physical activity on academic outcomes among youth, as indicated in multiple large-scale studies (Ahamad et al. 2007; Dwyer et al., 1988; Sallis et al. 1999; Shephard et al., 1984). Strong et al. (2005) compiled an expert panel review board under contract with the Division of Nutrition and Physical Activity and Adolescent and School Health of the CDC. The expert panel review board was composed of a multidisciplinary team with expertise in adiposity, and mental health domains of self-concept, academic achievement, and depression. The purpose of the review was to examine the literature for the evidence of the benefits of physical activity on a variety of outcomes for youth. The panel included indicators of academic performance such as grade point average, as well as indirect

indicators such as concentration and classroom behaviors, and included 17 studies specific to academic achievement outcomes. Based on a comprehensive review of included articles, each panelist supplied a designation for strength of evidence that physical activity has an impact on academic performance. Specifically, if they found that more than 60% of the studies reviewed related to academic performance had a positive effect, then the strength of the effect was labeled as strong, 30% to 59% of studies resulted in a label of moderate, and less than 30% of studies resulted in a label of weak. The direction of the relationship was also rated for each study as positive, null, or negative. Within the article, evidence was not shared concerning whether the effect was strong, moderate, or weak, but it was shared among the panelists, which resulted in discussions related to physical activity recommendations. The panel concluded physical activity has a positive effect on academic performance.

Tomporowski (2003) included measures of academic achievement as indicative of cognitive outcomes, so conclusions were not specifically made concerning the impact of physical activity on youths' academics. Upon review of the included studies, it was found that four studies measured the effect of physical activity on academic achievement. All four studies measured mathematical computation, two with nonclinical youth (Gabbard & Barton, 1979; McNaughten & Gabbard, 1993), one study on a child with ADHD (Molloy, 1989), and one on a child with intellectual disabilities (IND) (Croce & Horvat, 1995). All four studies found that a short bout of physical activity had a positive effect on increasing youths' mathematical computation skills. These literature reviews are in consensus with one another regarding the positive effect of physical activity on academic achievement in youth.

In sum, there are discrepancies in the specific academic areas that were improved as a result of engagement in physical activity and only one meta-analysis specifically investigated

this. In addition, there were many different measures used to determine academic achievement, and there were few studies that used experimental designs. A salient finding is that taking time away from academics for physical activity engagement does not hinder academics, thus providing evidence for keeping/including opportunities for physical activity within the school day (Ahamad et al., 2007; Dwyer et al., 1988; Sallis et al., 1999; Shephard et al., 1984). Although there have been numerous studies exploring the relationship between physical activity and children's academic achievement, more research is still needed to come to an agreement concerning whether physical activity significantly impacts children's learning outcomes.

Behavioral outcomes. There have been two meta-analytic reviews of the effects of physical activity on the behavior of children (Allison, Faith, & Franklin, 1995; Sowa & Meulenbroek, 2012). Allison et al. (1995) examined the effects of physical activity on externalizing behaviors, whereas Sowa and Meulenbroek (2012) examined the effects of physical activity on the behavior of children with ASD. Allison et al. (1995) examined the effects of physical activity on disruptive behaviors and conducted separate analyses for group-design studies versus single-case design studies. The researchers defined disruptive behaviors as any externalizing behavior that needed to be reduced, such as aggression, self-injury, and talking out in class. They included participants of all ages, including studies with children and adults, and individuals with intellectual deficits. Allison et al. (1995) conducted a comprehensive search of the literature, including data-base searches via PsychLit, Sociofile, Medline, NurseLit, Psychobooks, Dissertation Abstracts International, ERIC, a search from the National Technical Information Service, ancestry analysis on important studies, and searching intervention programs from the Association for Behavior Analysis and the Association for the Advancement of Behavior Therapy. The key search terms used for searching the databases included *exercise,*

physical activity, running, jogging, behavior, conduct, and *hyperactivity.* Among the group studies that were included in the analysis were studies that examined either the acute or the chronic effects of physical activity. However, all of the single-case design studies examined the acute effects. For the group-design studies, effect sizes were calculated from a post-test comparison of treatment group(s) and control group(s). For the single-case design studies, a multiple regression approach that estimated the effects of treatment on both the level and slope of behavior after controlling for any baseline trend was used. Within each study, the researchers compared data from the first non-treatment phase to the data from the last treatment phase. There were 42 studies reviewed and the authors found that 12 of 16 group studies resulted in positive outcomes with a weighted mean ES of 0.33. In addition 22 of 26 single-case design studies identified resulted in positive outcomes (ES d = 1.99). Although the study was not specific to children, a majority of the studies (15 of the 26) were conducted with youth. This is the only review that has included separate statistical analyses for single-case design studies out of all of the quantitative reviews on the effects of physical activity on cognitive, academic, or behavioral outcomes. Moderator analyses are described in a later section of the present study.

In the other quantitative review that examined the effects of physical activity on behavior, the researchers conducted a meta-analysis on studies from 1991-2011 that specifically analyzed the effects of physical activity interventions on the core symptoms of ASD (Sowa & Meulenbroek, 2012). The study was conducted in the Netherlands and the researchers searched the following databases: Web of Science, PiCarta, PsychInfo, ScienceDirect, SpringerLink, SAGE journals online, WILEY online library, and Google Scholar. The keyword search terms used included *Pervasive Developmental Disorders, autism, ASD, Autism Spectrum Disorder, ADHD, conduct disorder, Asperger,* and *PDD-NOS,* paired with the terms *sport, exercise,*

physical exercise, physical activity, aerobic, fitness, swimming, walk, jogging, and group exercise. Analysis inclusion criteria included the following: (a) studies published between 1991 and 2011, (b) children or adults with an ASD diagnoses, (c) the interventions had to involve physical exercise, and (d) data needed to be able to be obtained to calculate behavioral change. The researchers found 16 studies that met the four inclusion criteria. The average age of the participants was 13.6 years old and 13 of the 16 studies were conducted with youth. Studies examining acute and chronic effects of physical activity were included. Researchers in the studies that were included examined the following outcomes: social skills, motor skills, and communication skills. However, no studies were located in which communication skills were specifically examined, so this was not included in the analysis. The researchers conducted statistical analyses that were separated based on whether the physical activity was done in a group or individually. Researchers included three single-case design studies out of a total of 16 studies within their analysis. The statistical method these researchers used to synthesize the results was to calculate improvement scores between a baseline measurement and one immediately after exercise or program completion. The results indicated that both group physical activity and individual physical activity resulted in a significant improvement rate for social skills. Specifically, there was a 71.43% increase in social skills from baseline data to post intervention for the individual physical activity and a 26.37% increase for the group-based physical activity. A much more significant improvement rate was found when the participant was involved in individual physical activity. In conclusion, these authors posited that physical activity might be an effective treatment for helping with social skills of youth and adults with ASD. Moderator analyses were not performed, other than separating the results into whether the physical activity had been done in a group or individually.

Two narrative literature reviews examined the effects of physical activity on the behavior of children (Gapin, Labban, & Etnier, 2011; Tomporowski, 2003). Tomporowski (2003) examined studies looking at the acute effects of physical activity on the behavior of children with clinical disorders. There were 13 studies that met the inclusion criteria and all showed positive results. Based on this review, Tomporowski (2003) suggested that physical activity decreased disruptive behavior and increased desirable behavior in children with autism, intellectual disabilities, ADHD, and behavioral disorders. The second narrative review, Gapin, et al. (2011), reviewed the correlation between physical activity and behavior, specifically among youth with ADHD. This review does not indicate the methodologies concerning how the researchers found or included studies. These researchers stated that they included four related studies that they knew about, of which three were unpublished (Gapin & Etnier, 2010b; Tette, 2003; & Wendt, 2001), while one was published (McKune, Puatz, & Lombard, 2003). All of the researchers of these studies examined the chronic effect of physical activity, however since this effect was not a focus of the present study these results were not summarized.

Taken together, there have been many studies examining the acute effect of physical activity on the behavioral outcomes of youth with and without clinical diagnoses. Not one replication study was located and all of the studies vary in their design, intervention, and participant characteristics; however, both of the meta-analyses indicated a positive effect of physical activity for various behavioral outcomes as shown in the meta-analysis (Allison, Faith, & Franklin, 1995; Sowa & Meulenbroek, 2012) and all 13 studies included in the relevant literature review found a positive effect (Tomporowski, 2003).

Moderating Effects of Physical Activity

There are a variety of moderators that have been researched when examining the relationship between physical activity and cognitive, behavioral, and academic outcomes, as detailed in Table 1. Three primary types of moderators have been examined in the extant literature: participant, intervention, and study characteristics. Within this section, there is a review of the findings in the existing meta-analyses of the participant characteristics, then intervention characteristics, and, finally, the study characteristics.

In regards to participant characteristics, the moderating effect of grade range was studied in previous reviews (Erwin et al., 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003). As it is related to cognitive and academic outcomes, Fedewa and Ahn (2011) found the strongest effects for elementary-aged youth, but ESs for students in middle and high school were also significant. Sibley and Etnier (2003) found that all grade groups had ESs that were significant, but found the strongest effects for middle school students, followed by young elementary school-age students, then older elementary and high school students. Erwin et al. (2012) found that grade level did not moderate the effect of physical activity on youths' academic outcomes. It should be noted that Fedewa and Ahn (2011) combined the ESs of studies that examined cognitive outcomes and academic outcomes, and did not separate the analyses by each outcome variable separately. Extant studies mainly reported on grade range, but Allison et al. (1995) included age group as a moderator analyses. Allison et al. (1995) found no difference across age groups for single-case design studies examining youths' behavioral outcomes.

Another participant characteristic, specific disabilities, was not found to moderate the effect of physical activity for youths' cognitive outcomes (Sibley & Etnier, 2003). No moderator analyses on specific disabilities were conducted examining the effect of physical activity on

youths' academic or behavioral outcomes. However, in post hoc observations, Allison et al. (1995) found that the four studies with the largest ESs from group-design studies all defined their participants as hyperactive.

Fedewa and Ahn (2011) found a moderating effect of youths' cognitive status, in that youth who were cognitively impaired versus youth with typical neurodevelopment had ESs that were twice as large for both cognitive and academic outcomes. However, cognitive status was not found to moderate the effect on youth's behavioral outcomes (Allison et al., 1995). Also pertaining to moderator analyses of participant characteristics, Fedewa and Ahn (2011) found a moderating effect of youths' initial physical fitness level for cognitive outcomes, in that elite athletes received the greatest benefits as compared to normal and physically-disabled youth. Gender, socioeconomic status, and race/ethnicity were not analyzed for any of the outcome areas in the extant meta-analyses.

Pertaining to moderator analyses of an intervention characteristic, the moderating effect of duration was not found to moderate the effect for youths' academic and behavioral outcomes (Allison et al., 1995; Erwin et al., 2012) and was not analyzed for cognitive outcomes. The person who delivered the intervention (agent) was not found to moderate the effect on youths' cognitive or academic outcomes (Fedewa & Ahn, 2011) and was not examined for youths' behavioral outcomes.

Intervention type was found to moderate the effect on youths' cognitive and academic outcomes (Fedewa & Ahn, 2011). Specifically, aerobic physical activity resulted in a larger ES than perceptual motor training and physical education (Fedewa & Ahn, 2011). The type of physical activity also moderated the effect for youths' behavioral outcomes (Allison et al., 1995). The research indicated that non-aerobic physical activity had a larger ES than physical activity.

The intervention unit (the size of the group of youth who were involved in the physical activity intervention) was found to moderate the effect on youths' cognitive, academic, and behavioral outcomes. Specifically, for cognitive and academic outcomes, interventions implemented in small groups had the largest effect, then medium groups, followed by large groups and whole classes (Fedewa & Ahn, 2011). Additionally, mixed-gender groups were found to have more of an effect than single-gender groups for both cognitive and academic outcomes (Fedewa & Ahn, 2011). For behavioral outcomes, Sowa and Meulenbroek (2012) found that interventions delivered to an individual versus a group of participants had a larger effect for youth with ASD on social outcomes. The intensity of the physical activity and the location in which the physical activity was implemented were not analyzed for any of the outcome variables.

Pertaining to moderator analyses of a study characteristic, no moderating effect of publication status for youths' cognitive or academic outcomes was found (Fedewa & Ahn, 2011), however, Sibley and Etnier (2003) (cognitive outcomes) found a moderating effect. Specifically, that unpublished studies indicated a significantly larger effect size than published studies (Sibley & Etnier, 2003). Allison et al. (1995) found that unpublished studies had a significantly larger effect size than published studies for youths' behavioral outcomes.

Sibley and Etnier (2003) found a moderating effect for the type of outcome variable examined, specifically for youths' cognitive outcomes. Sibley and Etnier (2003) found that ESs were significant across a variety of types of cognitive outcomes except memory, with IQ being the largest. Fedewa and Ahn (2011) also found IQ to have a large effect size. Pertaining to youths' academic outcomes, Fedewa and Ahn (2011) found a moderating effect for the type of outcome variable examined. ESs were ranked from highest to lowest in this order: math

achievement, reading achievement, total achievement, other, grade point average, spelling/vocabulary, and science (Fedewa & Ahn, 2011). The moderating effect of the type of outcome variable examined was not studied in the extant meta-analyses on the effect of physical activity on youths' behavioral outcomes.

Fedewa and Ahn (2011) found no moderating effect concerning the country in which the study was conducted in for youths' cognitive outcomes or academic outcomes. However, Erwin et al. (2012) found a moderating effect for youth's academic outcomes, specifically studies conducted in Europe had a significantly larger ES than studies conducted in the U.S. The type of SCD, the amount of data points in the SCD, and the specific measures used were not analyzed for any of the outcome variables.

In terms of the exploration of variables that may moderate the relationship between physical activity and cognitive, academic, and behavioral outcomes, it is difficult to reach consensus, due to mixed findings on many of the variables. It is important for researchers to continue to synthesize findings though literature reviews, allowing for a comprehensive examination of potential moderating effects on the relationship between physical activity and youths' cognitive, academic, and behavioral outcomes.

Integration of Research Findings

As demonstrated above, it is important to integrate findings across the literature in order to develop a more complete picture of the consistent themes across a body of research. An important way of integrating the findings of multiple studies examining the same variables is through meta-analyses. However, single-case designs have typically not been included in most meta-analyses. To highlight the potential benefits of including SCD and to provide information on the state of research in this area, in this section, the following topics will be reviewed: (a)

features and benefits of single-case designs; (b) benefits of synthesizing research findings, particularly meta-analyses; (c) use of single-case design studies in meta-analyses; and (d) extant use of single-case designs in the meta-analyses in the field of studying the effects of physical activity on the cognitive, academic, and behavioral outcomes of youth.

Each single-case design begins with basic A-B (or baseline-intervention) phases, and then additional phases may be introduced through an A phase (no treatment) and then another B phase (treatment) (Riley-Tillman & Burns, 2009). During the A phase(s) of treatment, the DV is measured multiple times before the introduction of the intervention during the B phase(s) (Krysik & Finn, 2010). Then after the intervention has been implemented (B phase), the DV is measured on a regular basis. There are variations of these types of designs, creating a multitude of single-case design options (Owens, 2011). For example, there can be multiple participants or groups, and/or treatments. The purpose of this type of design is to understand if an intervention creates change (Krysik & Finn, 2010). This type of design has repeated data collection over time, showing small changes over time and the results are typically displayed graphically (Krysik & Finn, 2010).

SCDs have many benefits. One benefit of single-case design is that the documentation of the results of the treatment is systematic and there is frequent and repeated measurement of the DVs (Zhan & Ottenbacher, 2001). This allows the treatment effect to be analyzed using multiple observations, enabling the analysis of treatment effect changes over time (Owens, 2011). Moreover, this sort of design is more practical for practitioners, which shortens the distance between research and practice (Morgan & Morgan, 2001). Specifically in the school setting it is not usually appropriate to have a control group and this type of design does not call for randomization of participants (Riley-Tillman & Burns, 2009). In addition, replication of single-

Table 1. Moderating Effects of Participant, Intervention, and Study Characteristics Between Physical Activity and Youths' Cognitive, Academic, and Behavioral Outcomes Using Extant Quantitative Analyses

Type of Characteristic	Specific Characteristic	Cognitive Outcomes	Academic Outcomes	Behavioral Outcomes
Participant	Grade range	Strongest effects for elementary-aged students, but the ESs for middle and high school levels were similar (Fedewa & Ahn, 2011); Strongest effects for middle-school age students, then young-elementary age, then older elementary and high school students had the smallest effects (Sibley & Etnier, 2003).	Strongest effects for elementary-aged students, but the ESs for middle and high school level were similar (Fedewa & Ahn, 2011). Grade level did not moderate the effect (Erwin et al., 2012).	Not analyzed.
	Age range	Not analyzed.	Not analyzed.	No difference across age groups for single-case design studies. And not examined for group studies (Allison et al., 1995).*
	Gender	Not analyzed.	Not analyzed.	Not analyzed.
	Specific Disability	No differences across youth who were labeled as healthy, mentally impaired, or having physical disabilities (Sibley & Etnier, 2003).	Not analyzed.	Post hoc observation of the distribution of ESs showed that the four studies with the largest ESs from the group-design studies all defined their participants as hyperactive (Allison et al., 1995).
	Cognitive Status	ESs greater (twice as large) for youth who were cognitively impaired versus youth with typical neurodevelopment (Fedewa & Ahn,	ESs greater (twice as large) for youth who were cognitively impaired versus youth with typical neurodevelopment (Fedewa & Ahn, 2011).	No difference across students with developmental delays and those without delays for group design

Table 1. (Continued)

Type of Characteristic	Specific Characteristic	Cognitive Outcomes	Academic Outcomes	Behavioral Outcomes
		2011).		studies or single-case design studies (Allison et al., 1995).
	Race/Ethnicity	Not analyzed.	Not analyzed.	Not analyzed.
	Socioeconomic Status	Not analyzed.	Not analyzed.	Not analyzed.
	Physical Fitness Level	Elite athletes had the largest effect compared to normal and physically disabled youth (Fedewa & Ahn, 2011).	Not analyzed.	Not analyzed.
Intervention	Duration	Not analyzed.	No effect for duration (Erwin et al., 2012).	No effect for duration, for group and single-case design studies (Allison et al., 1995).
	Intensity	Not analyzed.	Not analyzed.	Not analyzed.
	Type	Aerobic activity resulted in a larger ES than perceptual motor training and physical education. Also, no significant effects were found for resistance training or combined training (Fedewa & Ahn, 2011); No difference found between types including: (a) resistance/circuit training, (b) PE programs, (c) aerobic exercise, and (d) perceptual-motor (Sibley & Etnier, 2003).	Aerobic activity resulted in a larger ES than perceptual motor training and physical education (Fedewa & Ahn, 2011).	Non-aerobic exercise had a larger ES than aerobic for group design studies and single-case design studies. However, there were only two studies that used non-aerobic exercise for group design studies. (Allison et al., 1995).

Table 1. (Continued)

Type of Characteristic	Specific Characteristic	Cognitive Outcomes	Academic Outcomes	Behavioral Outcomes
		researcher, PE specialist, and other) (Fedewa & Ahn, 2011).	& Ahn, 2011).	
	Location	Not analyzed.	Not analyzed.	Not analyzed.
	Unit	Small group interventions (less than 10) had the largest effect then medium groups, followed by large groups or whole classes (Fedewa & Ahn, 2011); In studies that used mixed-gender groups versus single gender, the former had larger ESs (Fedewa & Ahn, 2011).	Small group interventions (less than 10) had the largest effect then medium groups, followed by large groups or whole classes (Fedewa & Ahn, 2011); In studies that used mixed-gender groups versus single gender, the former had larger ESs (Fedewa & Ahn, 2011).	Individual interventions had a larger effect than group (2 or more participants) for youth with ASD specifically on social outcomes (Sowa & Meulenbroek, 2012).
Study	Published/Unpublished	No difference (Fedewa & Ahn, 2011). Unpublished studies indicated a significantly larger effect than published studies (Sibley & Etnier, 2003).	No difference (Erwin et al., 2012; Fedewa & Ahn, 2011).	No difference between published and unpublished group design studies (Allison et al., 1995). For single-case design studies unpublished studies had a significantly larger effect size than published studies (Allison et al., 1995).
	Outcome Type Measured	Effects were significant across a variety of different outcomes (math achievement highest, IQ, reading achievement, total achievement, other, grade point average, spelling/vocabulary, and science, respectively (Fedewa & Ahn, 2011); Found that effects were significant	Found that effects were significant across a variety of different outcomes (math achievement highest, IQ, reading achievement, total achievement, other, grade point average, spelling/vocabulary, and science, respectively (Fedewa & Ahn, 2011).	Not analyzed.

Table 1. (Continued)

Type of Characteristic	Specific Characteristic	Cognitive Outcomes	Academic Outcomes	Behavioral Outcomes
		across a variety of different types of cognitive outcomes (except memory, with IQ being the largest (Sibley & Etnier, 2003).		
	Type of SCD	Not analyzed.	Not analyzed.	Not analyzed.
	Study Country	No difference found between United States (U.S.) versus non-U.S. (Fedewa & Ahn, 2011).	No difference found between United States (U.S.) versus non-U.S. (Fedewa & Ahn, 2011); Study location moderated the effect in that Europe had a significantly larger effect than studies conducted in the U.S. (Erwin et al., 2012).	Not analyzed.
	Specific Measures	Not analyzed.	Not analyzed.	Not analyzed.

Note. * Allison et al., (1995) did separate analyses for group design studies versus single-case design studies, therefore everywhere there is a citation of this study it is indicated which type of study design found a moderating effect. For all of the other cited studies, the analyses did not separate based on study design.

case design studies is easier to implement then group-based studies, which improves the generalization of findings. Zhan & Ottenbacher (2001) stated that a decision made concerning an individual student's educational decisions using evidence-based research that was conducted on many participants may cause problems when those findings are applied to individual cases of students. SCDs concentrate on the variation in the treatment effect at the individual level, which has been found to vanish when the focus is on the average treatment effect, as in group comparison designs (Barlow, Nock, & Hersen, 2009).

According to Owens (2011), the use of single-case designs has become more prolific with researchers in varying fields, such as school psychology, education, special education, and behavioral intervention studies, and it is important for researchers to synthesize these results through meta-analytic techniques, just as has been done for group-design studies. Quantitatively integrating the results of multiple studies for a particular population or a specific DV, through a meta-analysis, is a useful way to combine the findings so that research is organized in a way that is useful for practitioners, other researchers, and decision makers (Owens, 2011). Meta-analysis, as a statistical method, was first introduced by Glass (1976), as a quantitative approach to summarize results of studies. Glass (1976) defined it as, "the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings" (p.3). Meta-analyses have multiple purposes, including the following: (a) identification of variables that may influence outcome variables, (b) summarizing the overall effectiveness of the treatment that is being analyzed, (c) and describing the body of research as a whole (Blimling, 1988; Busk & Serline, 1992). Meta analyses allow others to access the literature by integrating the findings of multiple studies using a systematic approach to analyzing the research and

generating conclusions (Owens, 2011). Kavale and Glass (1981) stated that research integration is needed to help legitimize the work of multiple researchers by allowing similar studies to be synthesized. Typically, meta-analyses include studies with control and treatment groups, but they should also include single-case research (Van den Noortgate & Onghena, 2008).

Using meta-analysis research design to analyze research from SCDs is a relatively new practice in the fields of psychology and education (Miller & Lee, 2013). There are various reasons that researchers often cite concerning why SCDs are not included in meta-analyses. The major reasons are that there is lack of control and considerable debate over the best way to calculate effect sizes for this type of study (Maggin, O'Keeffe, & Johnson 2011). However, according to Schlosser (2005), "while there is still some debate about what 'effect size' is most appropriate, the question of whether or not to synthesize single-subject experimental designs using meta-analytic techniques is no longer in question" (p. 376). Meta-analyses of single-case designs should be performed more frequently, considering (a) the validity of findings of well-designed single-case research, (b) increase in the use of such designs in the past few decades, and (c) single-case designs to deem interventions as evidence-based (Miller & Lee, 2013). When multiple SCD findings are aggregated together, then the overall treatment effect, as well as the individual treatment effect can be estimated (Van den Noortgate & Onghena, 2003). By integrating the findings of multiple single-case design studies, theoretically, the generalizability of the results of the individual cases increases (Riley-Tillman & Burns, 2009). In addition, it has been found that many studies with youth with disabilities or in a nonclinical setting are conducted utilizing single-case design because it is harder to have large numbers of participants when studying low incidence and small populations (Parker, Vannest, & Brown 2009). It is important to be able to synthesize single-case design studies for these populations and to analyze

any potential moderating variables.

Among the five quantitative reviews conducted on the effects of physical activity on youths' cognitive, academic, and behavioral outcomes (Allison, Faith, & Franklin, 1995; Erwin, Fedewa, Beighle, & Ahn, 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003; Sowa & Meulenbroek, 2012), only Allison et al. (1995) included single-case design studies in their quantitative analyses with adequate statistical methods. Sowa & Meulenbroek (2011) included three SCDs in the 16 studies analyzed in their meta-analysis study. However, separate analyses were not conducted for group versus single-case design studies. In the meta-analysis by Allison et al. (1995), the ES found for the SCDs was 1.99, as compared to an ES = .33 for the group designs. However, Allison et al.'s (1995) study was conducted almost 20 years ago, grouped the results of single-case designs studies conducted with youth and adults together, and included SCDs for solely behavioral outcomes (Allison & Faith, 1995). Given that the recent popularity of single case design study has increased in the fields of psychology and education (Miller & Lee, 2013), there is a great need to quantitatively synthesize their results to add to the overall findings in this field. Another large gap in the field is that there has never been a synthesis of the effects of physical activity on the cognitive and academic outcomes of youth for studies using SCDs. Single-case design studies conducted in the body of literature pertaining to the acute effects of physical activity on youths' cognitive, academic, and behavioral outcomes are important to include in the quantitative reviews of the field due to their many strengths. Including SCDs in quantitative reviews in this field could help provide a more comprehensive picture of outcomes in this area that includes studies and populations that may have been excluded from previous work.

Conclusion

The purpose of this study was to conduct a meta-analysis of single-case design studies that examined the effect of acute bouts of physical activity on the cognitive, academic, and behavioral outcomes of youth. This body of literature is in need of a quantitative synthesis that includes SCDs, considering the majority of the previous meta-analyses used group design studies. This, along with a comprehensive moderator analysis, provides a more accurate and detailed understanding of the effect of physical activity on youths' cognitive, academic, and behavioral outcomes. In addition, with the decline in the health status of our youth, the relationship this has to low levels of physical activity, the decline in physical activity opportunities in schools, and the importance of youth's cognitive, academic, and behavioral outcomes for optimal childhood and later adult functioning, the current study has important implications for youth and those who work with or care for youth.

Chapter III: Methods

In this chapter, a detailed account of the methods utilized in the current study is provided. There is a discussion of the two distinct phases of data collection undertaken, followed by a description of the delineatation of the types of methods used to conduct the present meta-analysis by these two distinct phases—phase 1 data collection (P1DC) and phase 2 data collection (P2DC). The chapter then highlights the various search strategies, as well as the inclusion and exclusion criteria for a study to be included in the current meta-analysis. Followed by a detailing of the various processes used to establish if a study meets the inclusion criteria and organization of the eligibility phases is provided. Then there is a detailed description of the system used to code the outcome variables and moderators, as well as how the data was extracted from the studies. Next there is a description of how members of a research team were utilized to assist with the data collection. This chapter concludes with a description of the statistical analyses used to analyze the data.

Overview of Data Collection Phases

In most subsections of this chapter, a description of two different data collection efforts, including (a) phase 1 data collection (P1DC) and (b) phase 2 data collection (P2DC) is provided. P1DC represents data collected through a prior study conducted by the ADHD research group led by Dr. Julia Ogg at the University of South Florida. The research group conducted a meta-analysis of the effects of physical activity on youths' cognitive, academic, and behavioral outcomes. Both group and single-case design studies were gathered as part of the larger project; however, only group designs were included in the larger group analyses. There were 11 studies

coded as single-case designs in P1DC. A description of the methods used as part of this group project (P1DC) will ensue. Additionally, there is a description of P2DC, which includes the additional data collection methods for the present study.

Search Strategies

Phase 1 data collection (P1DC). The research group utilized different search methods to locate studies. A comprehensive search was performed on relevant databases. The databases that were searched included: (a) PsychINFO, (b) ERIC, (c) OTSeeker, (d) SportDiscuss, (e) CINAHL, and (f) Dissertation Abstracts. The following keywords were searched on each database: (a) *physical activity,* (b) *physical education,* (c) *exercise,* (d) *cognition,*(e) *academic,* (f) *achievement,* (g) *IQ,* (h) *classroom behavior,* (i) *adolescent,* (j) *youth,* and (k) *children.* Some of the keywords were chosen by reviewing the prior meta-analyses, of which two provided keywords (Erwin, Fedewa, Beighle, & Ahn, 2012; Sibley & Etnier, 2003). Additionally, the logic for use of these keywords was due to their reference to the population, interventions, or outcomes of interest (Littell, Corcoran, & Pillal, 2008). Furthermore, symbols were utilized, such as * or &, depending on the search database, which expanded the keywords so that the database also searched for different versions of the root of the word (Littell et al., 2008). For example, adolescen* called for a search of adolescent, adolescents, and adolescence on PsychINFO. A time period of the past 50 years was used to search for articles from 1961-2011.

A secondary search method, called "foot chasing" (White, 2009), was utilized by searching the reference list of the previous meta-analyses (Allison et al., 1995; Erwin et al, 2012; Fedewa & Ahn, 2011; Sibley & Etnier, 2003; Sowa & Meulenbroek, 2012) and literature reviews (Best, 2010; Gapan et al., 2011; Tomporowski, 2003; Strong et al., 2005). For the meta-analyses that did not provide references of the included studies, the authors of these studies were

contacted to obtain the reference list (Fedewa & Ahn, 2011; Sibley & Etnier, 2003). These reference lists were received and also searched for relevant articles. An additional method of hand searching relevant journals was conducted to locate articles that did not emerge from the other search methods. The following journals were hand searched: (a) *Journals of Sport and Exercise Psychology*, (b) *Psychology of Sport and Exercise,* (c) *Research Quarterly for Exercise and Sport,* (d) *Journal of Sport Science,* and (e) *Medicine and Science in Sports and Exercise*. Finally, a search of the Institute of Education Sciences (IES) website was conducted.

Phase 2 data collection (P2DC). A summary of the literature search methods for the P2DC is shown in Table 2. First, all of the studies that met the eligibility criteria during the final phase of the P1DC for the P2DC eligibility review phases were included. Then a search for studies between the years 2012-2014 was conducted using the same search methods as in the P1DC: (a) a database search of the same databases and the same keyword search terms and method, but refining the search to include studies from 2012-2014 (not 1961-2011); (b) foot-chasing of the meta-analyses that included single-case designs (Allison et al., 1995; Sowa & Meulenbroek, 2012), and of any related meta-analyses published during 2012-2014, then a review of the reference list of these articles; as well as a, (c) hand search of the same journals from P1DC, but from publication years 2012-2014. After culling single-case design experiments from the various literature search methods and collection periods, then each study was evaluated on study inclusion criteria, which is described in the next section.

Inclusion Criteria

Phase 1 data collection. Inclusion for P1DC were:

1. The study independent variable (IV) is a physical activity intervention.
2. The study was conducted with school-aged children between the ages of 3 and 18.

3. The study was conducted from 1961-2011.
4. The researcher measured at least one of the DVs (e.g., cognitive, academic, or behavioral outcomes) in relation to a physical activity intervention. Some examples of cognitive outcomes include intelligence testing, memory, and processing speed. Some examples of academic outcomes include scores on standardized tests of achievement, academic subject grades, and curriculum-based measures. Some examples of behavioral outcomes include on-task, total time engaged, out-of-seat behaviors, self-injury, and aggressive acts.
5. An intervention required either pre/post-intervention measurement or a between groups comparison to a control group (this criteria included single-case designs).
6. Articles published in languages other than English were acceptable provided that a translation could be found. If a translation could not be found, this study was ruled out.
7. Dissertations were acceptable, provided they met the other criteria.

Phase 2 data collection. In order to be included in the present meta-analysis, clear criteria were established to help identify which studies are pertinent to inclusion in the data analysis. Please note that several of the inclusion criteria (criteria 1, 2, 4, 6 and 7) were the same as P1DC. Criteria 3 and 5 from P1DC were adapted to be relevant for the current study and two additional criteria (8 and 9) for P2DC were established. The located studies met the following criteria in addition to criteria 1,2, 4, 6, and 7 of P1DC.

3. The study was conducted from 2012-2014.

5. Articles must use a single-case design. This can include A-B-A-B designs, multiple baseline designs across subjects, A-B designs, multielement designs, and multitreatment designs.
8. The study provided enough quantitative data to allow a calculation of a stable effect size, which is defined as at least three data points assigned to the baseline phase as well as to the treatment phase (Swanson, 2000).
9. The study provided data to permit the calculation of effect sizes or it was obtained from the lead researchers.

Table 2. Search Strategies for P1DC and P2DC

Phase 1 data collection (P1DC)	**Phase 2 data collection (P2DC)**
A.) P1DC Studies from the final review phase and included after data extraction, *N* = 63 (*N*= 11 single-case design studies)	A.) Same databases and keywords as P1DC but 2012-2014 publications; databases included: PsychINFO, ERIC, OTSeeker, SportDiscuss, CINAHL, and Dissertation Abstracts; keywords will include: *physical activity, physical education, exercise, cognition, academic, achievement, IQ, classroom behavior, adolescent, youth, and children* B.) Foot-Chasing Methods: checked the citation lists and included study lists of all extant meta-analysis and literature reviews for single-case design studies (Allison et al., 1995; Sowa & Meulenbroek, 2012) and the meta-analyses found from publication years 2012-2014 C.) Hand-Searching Journals: publication years 2012-2014 in *Journals of Sport and Exercise Psychology, Psychology of Sport and Exercise, Research Quarterly for Exercise and Sport, Journal of Sport Science,* and *Medicine and Science in Sports and Exercise*

Exclusion Criteria

Phase 1 data collection. Studies that did not meet the inclusion criteria described above were excluded.

Phase 2 data collection. Studies that did not meet the inclusion criteria described above were excluded. This included studies that examined the effects of physical activity on health outcomes.

Study Eligibility Process

Phase 1 data collection. There were three phases of review in the group research study with set criteria for inclusion in each phase. The members of all phases of the review team included a professor with a Ph.D. in school psychology, and eight graduate students of school psychology with varying degrees of either a B.A., M.A., M. Ed, or Ed.S. The members of the team were trained on the inclusion criteria and eligibility phase requirements. Inter-rater reliability was gathered during each eligibility phase for 10% of the identified studies in that phase. If there was disagreement among the raters, then the particular study was brought to Dr. Julia Ogg's (the principal investigator) attention and was reviewed by the group until consensus was met. The calculation of inter-rater agreement was conducted through the following formula: agreements divided by the number of agreements plus disagreements, multiplied by 100. If, during the review process, a reviewer of any particular article was unsure if it should be included, then another reviewer reviewed the article and it was discussed with the original reviewer until consensus was met.

During the first phase of the eligibility review, the two eligibility criteria that were established included if the study a) involved physical activity and b) was an intervention study. At this stage, just the abstract of the article was reviewed. The decision to use these two criteria was made because this information should be available in reviewing just the abstract and it should have excluded a large portion of the studies. If the criteria could not be determined by only reviewing the abstract, then the reviewer read the entire article to make a determination.

During the second phase of eligibility review, the criteria used to determine eligibility included whether or not the study was conducted on youth between 3 to 18 years of age. The third and final phase involved a review of the abstract or article to see if the study measured one of the following outcomes: cognition (e.g., executive functioning or memory), academics (e.g., grades or standardized measures of achievement), and/or behavior (e.g., aggression or attention). In Table 3, the researcher for the present study provides a summary of the eligibility process for P1DC and includes the number of studies that were reviewed at each phase.

Phase 2 data collection. First, the researcher reviewed the studies from the P1DC for eligibility. These studies had already been reviewed using the first three phases described above with acceptable rates of inter-rater reliability (> 80%). Therefore, these studies underwent only the two final review phases to see if they met the criteria for the present study. First, the study was reviewed with Round 4 criteria (Is the study's design a single-case design?) to determine eligibility into the next review round. For this phase of the review, the abstract or article was reviewed to be able to determine if the study met the inclusion criteria for Round 4. For studies that were determined to be SCDs, then the results section of the study was used to determine if the study met Round 5 inclusion criteria. These criteria examined whether the researchers provided sufficient data for the proposed analyses determined by three or more data points for a baseline phase as well as a treatment phase (Swanson, 2012).

Second, the studies found through the P2DC literature search methods underwent all 5 phases of eligibility criteria, as described in Table 3. Those studies that made it through Phase 5 were included in the data analysis.

Organization of Eligibility Phases

Phase 2 data collection. Utilization of online technologies helped the organization and extraction of data necessary for the current study. To be exact, the citation and resource management system, RefWorks, was utilized for all of the online database searches. The lists of the studies that were found through the various eligibility phases were kept in separate folders within RefWorks. This organizational system allowed for the researcher to stay organized and enhance accurate reporting of data. This system also allowed the researcher to indicate how many studies were included or excluded at each phase.

The researcher downloaded the full articles and saved them into a DropBox folder called Thesis- Data Collection- Articles Pulled for ease of locating the studies for review rounds. The articles were located through the University of South Florida's library services. If a study was unavailable through the USF database system, then a request to the Interlibrary loan services was made. If after two weeks the study was still unavailable then the study was excluded.

Also, GoogleDocs was utilized to serve as a way for the principal investigator and graduate students helping with data collection to communicate about delegated responsibilities and track if a study met or did not meet criteria.

Coding System

Phase 2 data collection. Next the final studies were coded that met all eligibility review rounds criteria (final studies). The final studies (met Review Round 5 criteria) from P1DC and P2DC were combined (N = 24), however while coding there were many studies that did not met the inclusion criteria *(*N = 9). Therefore, a total of N = 15 studies were coded. A further accounting for the specific reasons why these studies did not met criteria is provided in Chapter

4. All final studies were coded utilizing the procedures described in the following sections. Therefore, the subsequent sections of Chapter 3 are no longer in need of delineation between the phase 1 (P1DC) and phase 2 data collection (P2DC) methods.

A coding database was developed in Google Docs that allowed for the data to be entered into an online database, so that all graduate students who helped with data collection could access and save the document simultaneously. The database from GoogleDocs is compatible with Excel and was exported to the Excel software program for later use. This technology was also used to organize the codes used during the coding of the data. The specific way that the variables were coded is described in the following section.

Categorization of Dependent and Independent Variables

Each article was reviewed and coded for a number of different characteristics that allowed the researcher to answer the proposed research questions. The data were coded and were then used to conduct descriptive and inferential analyses to provide insight into the big picture on research in this area. Articles were coded whether the ES was pertaining to cognitive, behavioral, or academic achievement outcomes as well as for the exact data points in both baseline and treatment phases. Each case was additionally coded for an extensive list of study characteristics, including participant characteristics, intervention characteristics, and study design characteristics. This process allowed for the statistical analyses of potential moderating variables. The particular participant characteristics that were coded include grade range, age range, gender, specific disabilities (diagnoses of clinical disabilities, such as ASD), cognitive status (if participants were described as having typical or atypical cognitive functioning), race/ethnicity, socio-economic status, and initial fitness level of the participant. The intervention characteristics that were coded included the total duration in minutes of a single bout of physical activity,

Table 3. Eligibility Review Process

Phase of Data Collection	Round #	Inclusion Criteria	Review Type	IRR** P1DC	IRR P2DC
P1DC already completed (*N* = 450) ; P2DC (*N* =293)	1	Does the intervention of the study involve physical activity?	Abstract review unless a full article review was needed to locate the information.	This was already Completed; 10% of studies with >80% IRR	10% of studies with 95% IRR
P1DC already completed (*N* = 256); P2DC (*N* = 209)	2.	Are the participants' school-aged youth between 3 to 18-years-old?	Abstract review unless a full article review was needed to locate the information.	This was already Completed; 10% of studies with >80% IRR	10% of studies with 95% IRR
P1DC (*N* = 77); P2DC (*N* = 87)	3.	Is a dependent variable in the study a cognitive, academic, or behavioral outcome?	Abstract review unless a full article review was needed to locate the information.	This was already Completed; 10% of studies with >80% IRR	10% of studies with 96% IRR
P1DC (*N* = 11)and P2DC (*N* = 21)	4.	Is the study a single-case design?	Abstract review unless a full article review was needed to locate the information.	Not applicable because the data from this point is now labeled as P2DC	10% of studies with 100% IRR
P1DC (*N* = 9) P2DC (*N* = 20)	5.	Is there enough data to calculate an ES? (3 data points in baseline phase and 3 in a treatment phase)?	Information found in the full article (within the Methods section).	Not applicable because the data from this point is now labeled as P2DC	10% of studies with 100% IRR
Exluded during coding for not meeting criteria (*N* = 9); Total Studies (*N* = 15)	Final Studies	Coded all variables into a GoogleDoc	Full article review	Not applicable because the data from this point is now labeled as P2DC	50% of studies with 93% IRR & 10% of the graphs to make sure the software is reliable with 95% IRR

*P2DC: includes: (a) P1DC final studies but this data only needs to go through phase 4 & 5 criteria (b) keyword search on databases using 2012-2014, all 5 phases needed, (c) foot-chasing, all 5 phases needed, (d) hand-searching journals, all 5 phases needed, (e) if any other methods of obtaining articles are used unexpectedly, these will need to undergo all 5phases

** IRR means inter-rater reliability.

intervention intensity, intervention agent (who delivered the intervention), physical activity type (running, cycling, etc.) the location of the intervention, and the unit of participants (group or individual). The study design characteristics that were coded included published/unpublished, outcome type measured (e.g., behavioral, cognitive, and/or academic), the type of single-case design utilized, country in which study was conducted, specific measures used (e.g., Woodcock Johnson, Conners-Teacher and Parent Report, etc.), type of single-case design, and how many data points are included in the case. In Table 4, the definitions and specific coding categories are provided for each of these variables. A priori coding categories were utilized, except for the categories titled physical fitness and intensity, due to prior research showing much variability in the units associated with each variable, these were later coded after consulting with a Ph.D. in Exercise Science.

Outcome Data Extraction

Baseline and treatment raw data points were extracted from the studies. In order to extract the data, the following order of methods was used: (1) obtaining raw data from studies; (2) through the use of the DataThief III (2006) computer software; this software precisely extracts the data from the graphs provided in studies through importing the graphs in .JPEG file format; 3) if the graph or data were provided then the authors of the study were contacted. If the authors were unable to send the data within two weeks, then those cases were excluded. If, after exhausting all of these methods, the researcher was unable to extract the data, then these cases were excluded.

Inter-rater reliability was gathered for the outcome data extraction methods. To assess the reliability of data extraction through use of DataThief III, 50% of the graphs were randomly selected and an independent coder used the software to extract data. These data were input into

Table 4. Description of Coding of Study Moderators

Type of Characteristic	Specific Characteristic	Definition	Coding Categories
Participant	Grade range	The school grade(s) of the participants.	To be coded as *N*, for each category: daycare, preschool to pre-K, kindergarten to 1st, 2nd-3rd, 4th-5th, 6th-8th, 9th-12th, not provided (np)
	Age range	The age of the participants.	To be coded as *N* for each category: 3-5, 6-8, 9-11, 12-14, 15
	Gender	The gender of the participants.	Male or female, or data not provided.
	Specific Disability	The clinical diagnostic label given to participants (e.g., ASD, ADHD, learning disability)	No disability, general education classroom students, ADHD, ASD, cognitive disabilities, behavioral disorders, other, not provided
	Cognitive Status	Whether the participants are developmentally delay or intellectually disabled or not.	Neurotypical, cognitively impaired, learning disabled, other, np
	Race/Ethnicity	The race/ethnicity of the participants.	Coded using categories typically used as part of the census polls: white/Caucasian, black/African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Two or More Races, Hispanic or Latino, White alone, not Hispanic or Latino, or not provided.
	Socioeconomic Status	The socioeconomic status of the participants.	Coded as *N* for household income under $29,999, $30,000 to $49,999, $50,000 to 99,999, 100,000 to 249,999, over 250,000, np
	Physical Fitness Level	The physical fitness level of the participants pre-intervention.	Coded without a priori categories, write exactly the terminology used by the researcher or not provided and then consultation with a Ph.D. in physical education to determine categories
Intervention	Duration	The total minutes of one individual session of the physical activity	0 to 10 minutes (min.), 10-30 min., 31-60 min., 61-90 min., 90 min. and above, other
	Intensity	The aerobic level of intensity of the physical activity.	Coded without a priori categories and then through consultation with a Ph.D. in physical education the categories were determined Mild, Moderate, or Vigorous
	Type	The type of physical activity the participants engage in.	There were two items coded for this specific characteristic. First, whether the physical activity is aerobic or anaerobic

Table 4. (Continued)

Type of Characteristic	Specific Characteristic	Definition	Coding Categories
			and secondly, the specific physical activity (e.g., aerobic-running, anaerobic-restorative yoga) or not provided.
	Agent	The person that delivers the intervention.	Classroom teacher, PE teacher, PE specialist, researcher, trainer, video, other, not provided
	Location	The specific place that the intervention is implemented.	Academic classroom, physical education, classroom pull-out, school location-exact location unspecified, laboratory setting, other, not provided
	Unit	How many participants are included in the intervention at the same time.	Individual-based, small group (< 10), medium group (10-30), large group (+30), whole class, other, not provided
Study	Published/Unpublished	Whether the study was published in a peer-reviewed journal or not.	Published, unpublished, unknown
	Outcome Type Measured	Whether the study measures a cognitive, academic, or behavioral outcome.	Yes or no responses for each outcome area. There will be a dropdown menu of yes or no for each domain (e.g. academics: yes or no; cognitive: yes or no, behavioral: yes or no)
	Type of SCD	The specific type of single-case design study.	AB design, ABAB, multiple baseline across subjects, multielement, multitreatment
	Study Country	Which country the study took place.	There will be two items to code for this specific characteristic. First, whether the study was conducted in the United States or not in the United States, and secondly, the specific country or not provided
	Specific Measures	The specific measures used to measure the dependent variables (e.g. Conners, WJ-III Cognitive, observation).	Coded as standardized measures, observations, rating scales, interviews, other, or not provided

the same GoogleDoc used for coding the study moderators. This information was stored automatically and allowed for multiple users to input information on the document simultaneously.

Team Involvement

Members of the University of South Florida school psychology ADHD research team were asked to volunteer to help with the search strategies. The research group is led by a professor with a Ph.D. in school psychology. An outline of the team's involvement in the data collection is provided:

Literature Search, as outlined in Table 1: The principal investigator completed this phase without team involvement.

Eligibility Review Rounds: The researcher and three volunteer graduate students from the ADHD research team assisted in the review phases.

Eligibility Review Rounds Training: The researcher conducted a two-hour training on the inclusion criteria, each review round phases' criteria, inter-rater reliability (IRR) methods related to inclusion criteria, and training on usage of RefWorks, DropBox, and GoogleDocs for organization of eligibility rounds for each graduate student, utilizing the same outline for the trainings.

Eligibility Review Rounds Reliability: For each eligibility review round, in order to calculate IRR, two raters reviewed 10% of the studies.

Data Coding Training: Once the data collection team identified all of the studies eligible for inclusion in this study, then a second two-hour training was held on IRR for coding variables, and GoogleDocs for coding of data. Part of this training included a group practice coding session. Specifically, each person coded the same article utilizing a specific set of directions

during the training for moderators, and then had a discussion to answer any questions and to address any concerns.

Data Coding Reliability: At this phase of data collection, 10% of the studies were reviewed by both reviewers for the coding of the data. During the coding of the studies, if coding disagreements occurred, then discrepancies were resolved through discussion. Common discrepancies were due to entry error.

Outcome Data Extraction Training: At the training listed above for coding the data, the team members also coded the outcome data from the practice article and questions were addressed.

Outcome Data Extraction Reliability: For raw data that were extracted without DataThief III (2006), 10% of the cases were reviewed by a second coder. When DataTheif III was used then 10% of the graphs that were used to obtain the data were randomly selected and an independent coder used the software to extract data.

Analyses

To answer the proposed research questions, hierarchical linear modeling was used. There have been multiple studies that provide evidence that hierarchical liner modeling (HLM) is a valid statistical tool to combine and analyze the data among cases in a study and across studies (Moeyaert, Ugille, Ferron, Beretvas, & Van den Noortgate, 2013a). The use of hierarchical linear models is a way to summarize the findings of multiple cases examined in the same or several studies. It is important to synthesize the results to understand the generalizability of the findings to see if the same effect will be found across studies and how large of an effect one may expect from a given intervention (Van den Noortgate & Onghena, 2007).

Another advantage of HLM is that it is easy to account for autocorrelation even when there are few observations per case (Van den Noortgate & Onghena, 2008). In other

words, HLM can address the fact that measurements closer in time to one another may be more related compared to later measurements in time. In addition, HLM can provide information on linear or nonlinear time trends within phases of the design, and variances within cases, across cases, and across studies (Moeyaert, Ugille, Ferron, Beretvas, & Van den Noortgate, 2013b). Given that these issues are key in single-case designs, HLM is particularly well-suited to synthesize SCD studies.

Standardization of Data

Prior to running the analyses, each DV in a study was standardized per case, since many ways different scales of measurement were used across studies. There was a focus on analyzing the data from the first phase change or AB transition phases, and not the data from additional phase changes within the same time series. Also another focus was on examining the change in level between phases versus change in trend. The method to do this was proposed by Van den Noortgate and Onghena (2008). Then an ordinary least squares (OLS) regression for each subject from a study was performed separately (i.e., by using Equation 1, described further below), which provided an estimate of the residual within-subject standard deviation ($\hat{\sigma}_{ejk}$). Then the individual score (Y'_{ijk}) was divided by the estimated residual within-subject standard deviation ($\hat{\sigma}_{ejk}$).

$$Y'_{ijk} = \frac{Y_{ijk}}{\hat{\sigma}_{ejk}} \tag{1}$$

By using this method to standardize scores, the scores are not impacted by the size of the treatment effect and therefore the treatment effect estimates are not biased. There were no cases

where there was no variability in both the baseline and treatment phases, therefore none were excluded for this reason. Additionally, there were no cases where there was no variability in one of the phases. If alternating treatment designs studies meet the inclusion criteria, then alternate analyses for these studies will be determined upon consulting a statistician. Then extracted data was imported into a data file in Statistics Analysis Software (SAS).

Hierarchical Model to Aggregate the Single-Case Data

After the data were standardized, then the effect sizes were calculated using the hierarchical model proposed by Van den Noortgate and Onghena (2003, 2008). This model has been validated through numerous studies (Ferron, Farmer, & Owens, 2010; Moeyaert et al., 2013a; Owens & Ferron, 2012; Shadish, Rindskopf, & Hedges, 2007; Van den Noortgate & Onghena, 2003, 2008).

The use of the restricted maximum likelihood procedure in SAS proc MIXED was utilized to estimate the model parameters (Littell, Milliken, Stroup, Wolfinger, & Schabenberger, 2006). The Satterthwaite method to get an estimate of the degrees of freedom was used for behavioral outcomes (Satterthwaite, 1941). This method was chosen because it has been found to give accurate confidence intervals for estimates of the average treatment effect for the analysis of two-levels of multiple-baseline data (Ferron, Bell, Hess, Rendina-Gobloff, & Hibbard, 2009). The Kenward-Rogers method was utilized for academic outcomes to calculate the degrees of freedom, which takes into account small sample sizes.

A four-level HLM was utilized for behavioral outcomes. The four-level structure was as follows: level one measurements were grouped by time series (level 2), which were grouped within cases (level 3), which were grouped within studies (level 4). For academic outcomes, a two-level HLM was conducted. The two-level structure included measurements for level one

grouped within cases (level 2). During the raw data extraction, no trends in the data were observed, therefore time was not added as a second predictor. The potential moderators were added on the equations at the highest numerical level for further analysis.

At the first level of the model, the regression equation shows the within-subject variability (Equation 1). Y_{ijkl} is the observed score on the i^{th} measurement occasion (i = 1,2, . . . I), for the j^{th} DV (j = 0,1, . . . J), for the k^{th} case (k = 0,1, . . . K), and for the l^{th} study (l = 0,1,…L) and was modeledas a function of D, a dummy coded variable that describes if the measurement occasion i from the j^{th} DV, of the k^{th} case, in the l^{th} study is part of the baseline phase (D_{ijkl} = 0) or the treatment phase (D_{ijkl} = 1).

$$Y_{ijkl} = \beta_{0jkl} + \beta_{1jkl}D_{ijkl} + e_{ijkl} \text{ with } e_{ijkl} \sim N(0, \square) \tag{2}$$

The coefficient β_{1jkl} is then interpreted as the immediate effect of the treatment on the j^{th} DV, for the k^{th} case, in the l^{th} study, whereas coefficient β_{0jkl} is the baseline level on the j^{th} DV, for the k^{th} case, in the l^{th} study.

At the second level of the model, the variation across DVs within a case is described using two equations:

$$\begin{aligned} \beta_{0jkl} &= \theta_{00kl} + u_{ojkl} \\ \beta_{1jkl} &= \theta_{10kl} + u_{1jkl} \end{aligned} \qquad \text{with} \begin{bmatrix} u_{0jkl} \\ u_{1jkl} \end{bmatrix} \sim N(0, \Sigma_u) \tag{3}$$

Overall, these equations show that the β coefficients from Equation 2 equate to a case specific baseline level (θ_{00kl}) with random error to account for variation across DVs, and a case specific

treatment effet (θ_{10kl}) with random error to account for variation across DVs.

At the third level, the case specifc regression coefficients are modeled as random errors from the study average baseline level (γ_{000l}) and the study average treatment effect (γ_{100l}) as follows:

$$\begin{aligned} \theta_{00kl} &= \gamma_{000l} + \nu_{00kl} \\ \theta_{10kl} &= \gamma_{100l} + \nu_{10kl} \end{aligned} \qquad \text{with} \begin{bmatrix} \nu_{00kl} \\ \nu_{10kl} \end{bmatrix} \sim N(0, \Sigma_{\nu}) \tag{4}$$

At the fourth level, the study level regression coefficients are modeled as random errors from the overall average baseline level (δ_{0000}) and the overall average treatment effect (δ_{1000}) as follows:

$$\begin{aligned} \gamma_{000l} &= \delta_{0000} + \omega_{000l} \\ \gamma_{100l} &= \delta_{1000} + \omega_{100l} \end{aligned} \qquad \text{with} \begin{bmatrix} \omega_{000l} \\ \omega_{100l} \end{bmatrix} \sim N(0, \Sigma_{\omega}) \tag{5}$$

Residuals at each of the four levels are presumed to be multivariate normally distributed (Moeyaert, Ugille, Ferron, Beretvas, & Van den Noortgate, 2013b). Theδ*'s* are the fixed effects referring to the mean regression coefficients. δ_{1000} represent the overall treatment effect (i.e., the immediate treatment effect averaged across DVs, cases, and studies.

Moderator Analysis

Hierarchical linear modeling provides for an approach to systematically examine moderator variables. The variety of procedures, interventions, and subject characteristics in

single-case studies allows for a source of information to identify variables that moderate the effect (Van den Noortgate, & Onghena, 2007). The moderators listed above in the following section, *Categorization of Variables* were analyzed unless the sample size did not allow for such analyses. More specifically, moderator analyses were conducted if there was at least five units at each level of the moderator variable An accurate accounting of which moderators could be analyzed is provided in Chapter 4. The moderators were added to the four-level model in order to investigate if they have an impact on the effectiveness of the treatment. They were set as fixed effects to minimize the iterations and add to the reliability in the analysis (Wang, Cui, & Parrila, 2011), and were added in at the appropriate level (i.e., case level moderators were added in at level 3, whereas study level moderators were added in at level 4). For example, to examine the potential moderation of a study characteristic, Y, Equation 5 was altered by adding Y as a predictor:

$$\begin{aligned} \gamma_{000l} &= \delta_{0000} + \delta_{0001}\, Y + \omega_{000l} \\ \gamma_{100l} &= \delta_{1000} + \delta_{1001}\, Y + \omega_{100l} \end{aligned} \qquad \text{with } \begin{bmatrix} \omega_{000l} \\ \omega_{100l} \end{bmatrix} \sim N(0, \Sigma_{\omega}) \tag{6}$$

Significance of the Current Study

With regard to the significance of this study for school psychologists, physical activity may be an additional evidence-based intervention available for use at multiple levels of tiered services in schools. Furthermore, the particular dependent variables (DVs) of interest—cognitive, academic, and behavioral outcomes—are all important to study, considering the contribution of each domain for youth to experience school success. The results of the study may provide information to school psychologists and other policy stakeholders to help with their decision-making concerning physical activity opportunities during the school day. Finally, another contribution is that the results of this study further validate the utility of the results from single-case design through aggregating the effects of single cases to obtain average treatment

effects. Single-case designs are practical for school psychologists and other educators to implement and by conducting a synthesis of single-case design studies it further validates the importance and weight of these types of studies.

Chapter IV: Results

This chapter presents the results of the statistical analyses that answer the research questions within the current study. Descriptive analyses are provided first, including the literature search methods descriptives, reasons for study exclusion during data coding, interrater agreement, study characteristics, participant characteristics, and intervention characteristics. Results from the hierarchical linear modeling for the effect of physical activity on youths' academic and behavioral outcomes are presented next. Subsequently, results of the moderator analyses follow. It should be noted that no cases examined a cognitive outcome as a dependent variable, so no findings related to the cognitive outcomes research questions are presented.

Descriptive Statistics

Literature search method descriptives. The literature search resulted in 15 studies that met all of the study inclusion criteria. Table 5 shows that there were numerous studies identified for each search method. Although many studies were found using the P2DC Database search method, the most beneficial search method was footchasing, whereby out of 26 located studies, 16 or 62% of the studies made it to Round 5, whereas for P2DC database 0.2% of the located studies made it to Round 5, and 0.16% of P1DC all search methods made it to Round 5.

There were nine studies excluded during the data coding stage of the study. Please refer to Table 6 for the detailed exclusion reasons. Two studies investigated the chronic effects of physical activity (Elsom, 1980; Packer-Hopke, 2012), four did not include the necessary data to

conduct analyses (Levinson & Reid, 1993; Prupas & Reid, 2001; Rosenthal-Malek & Mitchell, 1997;

Watters & Watters, 1980), one study could not be located (St. Germain, 1988), another did not conceptualize the independent variable as needed for the current study (Gordon, Handleman, & Harris, 1986), and McGimsey & Favell (1988) grouped subjects within the current study's age criteria along with subjects outside of the age criteria.

Interrater reliability for review rounds and data coding. The IRR score for each search method is shown in Table 7 and the IRR score for the data coding stage and use of the software, DataThief III (2006) is shown in Table 8. IOA for each stage ranged from 84% to 100% with most IOA above 90%, which suggested that it was appropriate to proceed with analyzing the data to determine the effectiveness of physical activity overall and across different moderators.

Characteristics of the included studies. Fifty-one participants were included across the 15 studies, and there were 81 time series across studies and participants, and 14 outcomes studied across all cases. The information regarding the various variables that were coded for the main and moderator analyses for study characteristics are included in Table 9.

As seen in Table 10 across the 81 time series, there were zero cognitive outcomes, 7 academic time series, and 74 behavioral time series. Due to this number, the main analyses could not be conducted to answer the research question concerning the effects of physical activity on youths' cognitive outcomes, nor the subsequent research questions related to the moderating effects of various variables on this effect. However, analyses could be performed for the other research questions related to the effect and potential moderators of physical activity on youths' behavioral and academic outcomes.

As shown in Table 10, the most frequent type of study design was alternating treatments (49.38%), followed by AB design (29.63%), and then ABAB (20.99%) design. This was enough data to calculate the moderating effects. For specific outcome, which described the exact type of behavioral or academic outcome dependent variable, there was not enough data to calculate a moderating effect. Engagement or on-task behavior was the most frequent outcome studied (19.75%), self-stimulation was the next most frequent (18.52%), followed by off-task behaviors (12.35%). The majority of time series were published (72.84%) and this variable, whether the time series was published or unpublished, had enough data to analyze the potential moderating effect of publication status on youths' behavioral outcomes. Behavioral observations were used by almost all of the time series as the type of measurement method (92.59%) and the data were not suitable for moderator analyses. The location of the cases were mainly the United States (91.36%) and one study or seven time series, were conducted in Canada. The study location data were not enough to use for moderator analyses due to the seven time series coming from one study.

The information regarding the various variables that were coded for the main and moderator analyses for participant characteristics are included in Table 11 and the frequency of these variables in Table 12. The age ranges of the participants in the time series were found to be 32.10% in the 3 to 5 year old range, followed by 27.16% in the 9 to 11 year old range, 9.88% in the 15 to 18 year old range, 8.64% in the 6 to 8 year old range, 6.17% in the 12 to 14 year old range, and 16.05% not provided. In terms of grade range, the frequency of pre-kindergarten (18.52%), elementary aged youth (16.05%), middle school aged youth (16.05%), and high school aged youth (8.64%) was very similar; however, 40.74% did not provided this information. Of the time series, 92.60% were conducted on youth with special needs. Specifically 39.51% had a

behavioral disorder diagnosis, 28.40% had a diagnoses of Autism Spectrum Disorder, and 24.69% a cognitive disability. Of the remaining time series, 3.70% were conducted on youth in a general education classroom and 3.70% did not provide this information. The frequency of cognitive status was found to be 49.38% of times series had participants that were cognitively impaired, while 39.51% were neurotypical, and 11.11% did not provide the information. Race/ethnicity was not provided in 45.68% of the time series, while 40.74% of the time series were conducted on white youth, and 13.58% on black youth. Socioeconomic status was not provided in 100% of the time series. Information on the physical fitness level of the participants was not included for any time series.

Table 13 provides the descriptive information of the intervention characteristics in each study while Table 14 provides the number of time series per study and the frequency of the intervention characteristics by total time series ($N = 81$). The majority of the physical activity interventions for all time series were between 10-30 minutes in duration (62.96%), while 24.69% of time series had interventions lasting 0-10 minutes, and 12.35% did not provide the information. In terms of the intensity level of the physical activity, 30.86% of the time series had a mild physical activity intervention, 14.81% had moderate intensity levels, 22.22% had vigorous intensity levels, and the largest percentage, 32.10% of cases did not provide this information. There were many different types of physical activity among the cases, with 39.77% of cases having a jogging physical activity, 27.27% had varied-aerobic physical activity, 11.36% varied-anaerobic, 11.36% yoga, 6 time series all from one study, had chase as the physical activity (6.82%) , and one study or 3 time series had roller-skating (3.41%). In terms of the agent, or who conducted the intervention, the largest percent of time series had a researcher as the agent (61.73%), followed by between 3%-11% for the other types of agents. The majority of the cases

conducted the physical activity at an individual level (66.67%) while 29.63% at a small group level and 3 time series, all part of 1 study, conducted it at a class wide level (3.70%). The most frequent location of the intervention for all time series was the schoolyard (50.62%), followed by the classroom (16.05%), school gym (14.81%), residential institution (11.11%), and a research lab for one study or six cases (7.41%). In sum there was much variability among the case, study, and participant characteristics.

Inferential Analyses

There were 15 included studies in the data analysis and multiple time series per study for a total of $N = 81$ time series, and a total of $N = 51$ cases. There were 74 effect sizes that were synthesized to create the overall effect of physical activity on youths' behavioral outcomes and 7 effect sizes for the overall effect of physical activity on youths' academic outcomes, and 0 effect sizes for the overall effect on youths' cognitive outcomes. After coding the data points of each dependent variable, the data were transformed into standardized scores. It was observed that the hierarchical linear model had four levels. These levels included observations nested within outcomes, nested within cases, nested within studies. For the analysis of the effect of physical activity on the behavioral outcomes of youth a total of 999 individual observations were nested within 74 time series, nested within 51 cases, nested within 15 studies. For the analysis of the effect of physical activity on the academic outcomes of youth a total of 192 individual observations were nested within 7 time series, within 7 cases, which came from 2 studies.

Behavioral outcomes. The four-level hierarchical linear model without moderators is presented in Table 15. This analysis shows that on average physical activity interventions are significantly effective in comparison to the baseline conditions for changing youths' behavioral outcomes. Specifically it was found that the level of desirable behaviors is 1.83 (95% CL 0.89 to

2.77, p = 0.001) standard deviations higher in the treatment conditions, which is statistically significant. Looking at the covariance parameter estimates in Table 16, the intervention effects vary significantly over time series within a case (i.e., across the multiple dependent variables within a case), with an estimated variance of 0.58, $Z = 1.73$, $p = .0419$. The intervention effects also vary significantly for the cases, with an estimated variance of 1.26, $Z = 2.07$, $p = .019$, and they vary significantly over the studies, with an estimated variance of 2.11, $Z = 2.09$, $p = .01$. The residual within participants' variance is 1.003, which means the standard deviation within a time series is about 1.0, which was expected because the data had been standardized within time series.

Moderator analyses for behavioral outcomes. In order to examine the research questions related to which variables moderate the relationship between the effect of physical activity on youths' behavioral outcomes refer to Table 17. Table 17 shows a statistically significant moderating effect of the variable *Type of SCD* ($F (3, 865) = 4.19$, $p = .0059$). The specific type of SCD that had a moderating effect was ABAB designs in comparison to the reference variable, alternating treatments ($t (865) = 3.50$, $p = .0005$). ABAB was compared to alternating treatments and it was found that there was a statistically significant difference, with ABAB designs having the larger effect. None of the other study, intervention, or participant variables moderated the effect of physical activity on youths' behavioral outcomes. The specific outcome variable (e.g., aggression, on-task behavior, and stereotypic behavior was not able to be analyzed due to a small *n* of cases and observations per outcome.

Academic outcomes. Among the data, there was one specific academic outcome variable studied, which was work completion and thus there was no nesting of specific dependent variables within cases. In addition, there were only two studies, which was not

enough to nest the cases within studies. As a consequence, a two-level hierarchical linear model was estimated where observations were nested within cases. Since the number of cases ($N = 7$) that analyzed the effect of physical activity on youths' academic outcomes is a small sample size the Kenward-Roger approach was used for the degrees of freedom estimate, which makes an adjustment for the small sample size. The estimates from the two-level model without moderators are presented in Table 18. This analysis shows that on average the physical activity interventions for academic outcomes are significantly effective in comparison to the baseline conditions. Specifically, the level of desirable academic behavior is 2.01 (95% CL 1.6205 to 2.4039, $p = <0.0001$) standard deviations higher in the treatment conditions, which indicates a large effect size. Looking at the variance parameter estimates in Table 19. The between case variance for the treatment effect was estimated to be 0.02 and was not statistically significant, $Z = 0.22$, $p = 0.4123$. The residual within participants' variance is 0.9977, which means the standard deviation within a time series (or case) is about 1.0, which was expected because the data had been standardized within time series.

Moderator analyses for academic outcomes. Because there was not significant variance in the treatment effects across cases there was not empirical evidence to conduct a moderator analysis. Furthermore, because all of the potential moderators are case or study characteristics and there were only 7 cases, there was not enough available information to conduct moderator analyses. It was decided a priori to only pursue moderator analyses if there were at least five cases at one level of the moderator to contrast with at least five cases at another level of the moderator.

Table 5. Literature Search Methods Descriptives

Eligibility Review Round	P1DC all search methods	P2DC Databases	P2DC Handsearch	P2DC Footchasing	P2DC Other	Total
Initial	5506	1992	12	26	0	
Round 1	450	257	10	26	0	
Round 2	256	178	5	26	0	
Round 3	77	62	4	21	0	
Round 4	11	5	0	16	0	
Round 5	9	4	0	16	0	29
Duplicates from P1DC and P2DC						5
Excluded During Data Coding						9
Total Studies						15

Table 6. Reasons for Study Exclusion During Coding of Data

Author	Study Title	Reason for Exclusion
Levinson & Reid (1993)	"The Effects of Exercise Intensity on the Stereotypic Behaviors of Individuals with Autism"	Principal investigator emailed the researcher as the study did not include the data points. The researcher did not respond.
Elsom (1980)	"Self-Management of Hyperactivity: Children's Use of Jogging"	Studied chronic effects of physical activity.
Gordon, Handleman, & Harris (1986)	"The Effects of Contingent versus Noncontingent Running on the Out-of-Seat Behavior of an Autistic Boy"	Physical activity was used as a consequence of inappropriate behavior. The purpose of the study was not

Table 6. (Continued)

Author	Study Title	Reason for Exclusion
		to see the acute effects of physical activity but rather if physical activity was used as a punishment did it change behavior.
Packer-Hopke (2012)	"Effect of Aerobic Exercise on Childhood Tourette Syndrome and Obsessive-Compulsive Disorder Symptoms"	Studied chronic effects of physical activity.
Prupas & Reid (2001)	"Effects of Exercise Frequency on Stereotypic Behaviors of Children with Developmental Disabilities"	Did not include enough data for baseline and treatment phases. The primary researcher was contacted for the data.
Rosenthal-Malek & Mitchell (1997)	"Brief Report: The Effects of Exercise on the Self-Stimulatory Behaviors and Positive Responding of Adolescents with Autism"	Did not include baseline data. The primary researcher was contacted for the data.
Watters & Watters (1980)	"Decreasing Self-Stimulatory Behavior with Physical Exercise in a Group of Autistic Boys"	Did not include the data in raw or graph form. The primary researcher was contacted for the data.
McGimsey and Favell (1988)	"The Effect of Increased Physical Exercise on Disruptive Behavior in Retarded Persons"	The data did not discern the ages of subjects between 15-25 years of age, so the study could not be included due to it not meeting age requirements. The primary researcher was contacted for the data.
St. Germain (1988)	"The Effect of Running on Attention Span, Impulse control, and Academic Achievement of Children with Learning Disabilities"	Full article cannot be located.

Table 7. Interrater Reliability Calculations Per Review Round

Review Round	P2DC Database IOA	Footchasing IRR	Handsearching IRR	P1DC Final Studies	Average IRR
1	84.42%	100%	100%	N/A	94.8%

Table 7 (Continued)

Review Round	P2DC Database IOA	Footchasing IRR	Handsearching IRR	P1DC Final Studies	Average IRR
2	84.62%	100%	100%	Not applicable	94.87%
3	88.89%	100%	100%	Not applicable	96.3%
4	100%	100%	No studies	87.5%	100%
5	100%	100%	No studies	100%	100%
				Avg IOA across search methods	97.19%

* IRR is an abbreviation for interrater reliability

Table 8. Interrater Reliability Calculations During Data Coding

	Percent of Studies Calculated	IRR
Data Coding	10%	93%
Graphs	50%	90%

Table 9. Study Characteristics Per Included Study

Study	Type of Design	Outcome Measured	Specific Outcome	Published	Study Location	Specific Type of Measure
Bachman & Fuqua (1983)	Alternating treatments	Behavioral	Mixture of Off Task, Self-Stimulation	Yes	United States	Behavioral Observations
Celiberti, Bobo, Kelly, Harris, & Handleman (1997)	AB Design	Behavioral	Self-Stimulation	Yes	United States	Behavioral Observations
Currier (2012)	AB Design	Behavioral	Appropriate Vocalizations; Engagement/On Task; Self Stimulation; Protesting; Screaming;	Yes	United States	Behavioral Observations
Evans (2013)	AB Design	Academic; Behavioral	Verbal Off-Task at School; Work Completion	Yes	United States	Behavioral Observations
Kern (1982)	2 studies were AB Design; 4 alternating	Academic; Behavioral	Self Stimulation; Work Completion; Engagement/On Task	Yes	United States	Behavioral Observations
Kern (1984)	Alternating Treatments	Behavioral	Self Stimulation	Yes	United States	Behavioral Observations
Lancioni et al., (1984)	Alternating Treatments	Behavioral	Self-Injurious Behaviors	No	United States	Not provided
Mahar (2006)	Alternating Treatments	Behavioral	Engagement/On Task	Yes	United States	Behavioral Observations
Mays (2013)	ABAB	Behavioral	Self Stimulation	Yes	United States	Behavioral Observations
Morrison (2011)	Alternating	Behavioral	2 Self Stimulation; 1 Self	Yes	United States	Behavioral

Table 9 (Continued)

Study	Type of Design	Outcome Measured	Specific Outcome	Published	Study Location	Specific Type of Measure
	Treatments		Injurious Tantrums			Observations
Peck (2005)	Alternating treatments	Behavioral	Engagement/On Task	Yes	United States	Behavioral Observations
Powers (1992)	Alternating treatments	Behavioral	1 Self Stimulation; 1 Engagement/On Task	Yes	United states	Behavioral Observations
Rommel (2013)	Alternating treatments	Behavioral	Engagement/On Task	No	Canada	Behavioral Observations
Yell (1988)	ABAB	Behavioral	Motor Off Task School Behaviors	Yes	United States	Behavioral Observations
Vail (1989)	Alternating treatments	Behavioral	3 Positive Social Skills; 1 Negative Social Skills; 3 Negative Play Skills; 3 Positive Play Skills;	No	Study Country	Behavioral Observations

Table 10. Study Characteristics Frequency by Time Series

Study Characteristic	Total Number of Time Series	% For each subcategory	Enough Data For Analyses
Type of SCD			Yes
Alternating Treatments	40	49.38%	
AB	24	29.63%	
ABAB	17	20.99%	
Outcome Measured			Yes
Cognitive	0	0.00%	
Academic	7	8.64%	
Behavioral	74	91.36%	
Specific Outcome			No
Mixture of Off Task, Self Stimulation	4	4.94%	
Self Stimulation	15	18.52%	
Appropriate Vocalizations	1	1.23%	
Engagement/On Task	16	19.75%	
Protesting	1	1.23%	
Screaming	11	1.23%	
Off Task	10	12.35%	
Self Injurious Behaviors	7	8.64%	
Positive Play Skills	8	9.88%	
Negative Play Skills	3	3.70%	
Positive Social Skills	3	3.70%	
Negative Social Skills	1	1.23%	
Motor Off Task	4	4.94%	
Work Completion	7	8.64%	
Publication Status			Yes
Yes	59	72.84%	
No	22	27.16%	
Specific Type of Measurement			No
Behavioral Observations	75	92.59%	
Not Provided	6	7.41%	
Study Location			No
United States	74	91.36%	
Canada	7	8.64%	

Table 11. Participant Characteristics of Included Studies

Study	N of Participants	Grade Range	Age	Gender	Specific Disability	Cognitive Status	Race/Ethnicity	SES
Bachman & Fuqua (1983)	4	Not provided	6 to 16 years old, mean age of 9	Male	Cognitive Disabilities	Cognitively Impaired	Not provided	Not provided
Celiberti et al. (1997)	1	Elementary	3 to 5 years old	Male	Autism Spectrum Disorder	Not provided	White	Not provided
Currier (2012)	1	Not provided	3 to 5 years old	Male	Autism Spectrum Disorder	Not provided	Not provided	Not provided
Evans (2013)	6	Middle School	9-11 years old	Not provided	Behavioral Disorder	Neurotypical	White	Not provided
Kern (1982)	6	Not provided	2, 3-5 year old range; 1 in 6-8 year old range; 1 in 9-11 year old range; 2 in 12-14 year old range;	3 male; 3 not provided	Autism Spectrum Disorder	Cognitively Impaired	Not provided	Not provided
Kern (1984)	3	Not provided	1 subject in 6-8 year old range; 2 in 9-11 year old range	Not provided	Autism	Cognitively Impaired	Not provided	Not provided
Lancioni et al. (1984)	3	Not provided	1 subject 9-11 years old; 1 subject 12-14 years old; 1 subject 15-18	2 male; 1 female	Blind; Deaf; Blind & Deaf; & Cognitive Disabilities	Cognitively Impaired	Not provided	Not provided

Table 11. (Continued)

Study	N of Participants	Grade Range	Age	Gender	Specific Disability	Cognitive Status	Race/Ethnicity	SES
Mahar et al. (2006)	4	Elementary Aged	Not provided, Entire Classes	Not provided	General education classroom students	Not provided	Not provided	Not provided
Mays (2013)	2	Not provided	9 to 11 years old	1 male, 1 female	Autism Spectrum Disorder	Cognitively Impaired	Not provided	Not provided
Peck (2005)	3	Elementary School	Not provided per case	Not provided	Not provided	Not provided	Not provided	Not provided
Powers (1992)	1	Not provided	6-8 years old	Female	Cognitive Disability	Cognitively Impaired	Not provided	Not provided
Rommel (2013)	7	High school	15-18 years old	4 female, 3 male	Cognitive Disabilities	Cognitively Impaired	2 Black, 5 white	Not provided
Vail (1989)	4	Pre -K	3 to 5 years old	Male	Behavioral Disorders	Neurotypical	2 Black, 2 White	Not provided
Yell (1988)	6	Elementary School	3, 6-8 year old; 3 9-11 year olds	Male	Behavioral Disorders	Neurotypical	White	Not provided

Table 12. Participant Characteristics Frequency by Time Series

Variable	Total Number of Time Series	% For each subcategory	Enough Data For Analyses
Grade Range			Yes
Pre Kindergarten	15	18.52%	
Elementary	13	16.05%	
Middle School	13	16.05%	
High school	7	8.64%	
Not Provided	33	40.74%	
Age Range (years old)			Yes
3 to 5	26	32.10%	
6 to 8	7	8.64%	
9 to 11	22	27.16%	
12 to 14	5	6.17%	
15 to 18	8	9.88%	
Not Provided	13	16.05%	
Gender			Yes
Male	44	54.32%	
Female	10	12.35%	
Not Provided	27	33.33%	
Specific Disability			Yes (not general education classroom)
Autism Spectrum Disorder	23	28.40%	
Behavioral Disorders	32	39.51%	
Cognitive Disabilities	20	24.69%	
General Education Classroom	3	3.70%	
Not Provided	3	3.70%	
Cognitive Status			Yes
Cognitively Impaired	40	49.38%	
Neurotypical	32	39.51%	
Not Provided	9	11.11%	
Race/Ethnicity			Yes
White	33	40.74%	
Black	11	13.58%	
Asian	0	0.00%	
Hispanic	0	0.00%	
Native American	0	0.00%	
Not provided	37	45.68%	
SES			No
Not provided	81	100%	

Table 13. Intervention Characteristics Per Included Study

Study	N of Cases	Duration	Intensity	Type of Physical Activity	Agent	Location	Unit
Bachman & Fuqua (1983)	4	Not provided	Moderate	Jogging	Researcher	School Gym	Individual
Celiberti et al. (1997)	3	0-10 minutes	Mild	Jogging	Researcher	School Yard	Individual
Currier (2012)	6	Not provided	Mild	Chase	Researcher	School Gym	Individual
Evans (2013)	13	10-30 minutes	Mild	Jogging	Researcher	School Yard	Individual
Kern (1982)	6	0-10 minutes	Moderate	Jogging	Not provided	School Yard	Individual
Kern (1984)	3	10-30 minutes	Vigorous	Jogging	Researcher	Lab	Individual
Lancioni et al. (1984)	6	10-30 minutes	Not provided	Varied – Aerobic	Researcher	Residential Institution	Individual
Mahar et al. (2006)	3	0-10 minutes	Not provided	Varied – Aerobic	Classroom teacher	Classroom	Class wide
Mays (2013)	2	0-10 minutes	Moderate	Jogging	School employee	School gym	Small Group
Morrison (2011)	3	0-10 minutes	Not provided	Varied-Anaerobic	Therapist	Lab	Individual
Peck (2005)	3	10-30 minutes	Mild	Yoga-Anaerobic	Not provided	Classroom	Small Group
Powers (1992)	3	0-10 minutes	Not provided	Roller-skating	School employee	Residential Institution	Individual
Rommel (2013)	7	10-30 minutes	Not provided	Yoga-Anaerobic	Video	Classroom	Small group
Vail (1989)	15	10-30 minutes	Vigorous	Varied-Aerobic	Researcher	School yard	Mixture of Individual or Small group
Yell (1989)	4	10-30 minutes	Not provided	Jogging	Classroom Teacher	School yard	Small group

Table 14. Frequency of Intervention Characteristics by Time Series

Variable	Number of Time Series	Frequency Percentage	Enough Data for Analyses (> 5 per category)
Duration			Yes
0-10 Minutes	20	24.69%	
10-30 Minutes	51	62.96%	
Not Provided	10	12.35%	
Intensity			Yes
Mild	25	30.86%	
Moderate	12	14.81%	
Vigorous	18	22.22%	
Not Provided	26	32.10%	
Type of Physical Activity			Yes (not roller-skating)
Jogging	35	39.77%	
Chase	6	6.82%	
Varied-Aerobic	24	27.27%	
Varied-Anaerobic	10	11.36%	
Roller-skating	3	3.41%	
Yoga	10	11.36%	
Agent			
Researcher	50	61.73%	Yes (not therapist)
Classroom Teacher	7	8.64%	
School Employee	5	6.17%	
Video	7	8.64%	
Therapist	3	3.33%	
Not Provided	9	11.11%	
Unit			Yes (not class wide)
Individual	54	66.67%	
Small Group	24	29.63%	
Class wide	3	3.70%	
Location			Yes
School Gym	12	14.81%	
School Yard	41	50.62%	
Lab	6	7.41%	
Residential Institution	9	11.11%	
Classroom	13	16.05%	

Table 15. Results of the 4-level HLM Final Estimation of Fixed Effects for Behavioral Outcomes

Fixed effect	Coefficient	SE	*T*-Value	Approx. d.f.	*p*-Value
Intercept	5.08	1.21	4.18	13	.0011
Tx	1.83	0.44	4.20	13	.0010

Table 16. Covariance Parameter Estimates

Variance Parameter Estimates				
Parameter	Estimate	SE	Z	*p*-value
Variance in Treatment Effects				
Between Time Series	0.58	0.33	1.73	.0419
Between Cases	1.26	0.61	2.07	.0192
Between Studies	2.11	1.01	2.09	.0181
Variance in Baseline Levels				
Between Time Series	5.48	2.35	2.33	.0099
Between Cases	16.52	5.62	2.94	.0016
Between Studies	14.66	8.42	1.74	.0408
Variance Within Time Series	1.00	.048	20.82	<.0001

Table 17. Moderator Effects Statistics on the Effect of Physical Activity on Youths' Behavioral Outcomes

Moderator	Estimate	Standard Error	DF	*t* Value	Pr > |t|
Study Characteristics					
Publication Status					
Published	0.7449	0.9872	866	0.75	0.4507
Unpublished	0	-	-	-	-
Type of SCD					
AB	0.1926	0.7372	865	0.26	0.7939
ABAB	*3.3352	0.9527	865	3.50	0.0005
Multiple Baseline Across Subjects	-0.02837	0.9000	865	-0.03	0.9749
Alternating Treatments	0	-	-	-	-
Study Country					
United States	0.6140	1.6883	867	0.36	0.7162
Canada	0	-	-	-	-
Specific Measures					
Permanent Product	-0.2014	0.5676	841	-0.35	0.7229
Observations	0	-	-	-	-
Participant Characteristics					
Race					
White/Caucasian	0.3512	1.0825	477	0.32	0.7457
Black/African American	0	-	-	-	-

Table 17. (Continued)

Participant Characteristics					
Grade Range					
Moderator	**Estimate**	**Standard Error**	**DF**	***t* Value**	**Pr > |t|**
Elementary	0.1711	1.7836	441	0.10	0.9236
Middle School	0	-	-	-	-
High School	-0.3203	1.2834	867	-0.25	0.8030
Age Range (years old)					
3 to 5	-0.2811	2.1230	867	-0.13	0.8947
6 to 8	0.4009	2.0560	867	0.19	0.8454
9 to 11	-0.4255	2.0457	867	-0.21	0.8353
12 to 14	-0.02550	2.0815	867	-0.01	0.9902
15 to 18	0.8906	2.2962	867	0.39	0.6982
6 years to 16 (mean age 9)	0	-	-	-	-
Gender					
Female	1.1023	0.8015	545	1.38	0.1696
Male	0	-	-	-	-
Specific Disability					
General education students	-1.0690	1.9404	821	-0.55	0.5819
Autism Spectrum Disorder	-1.3077	1.1516	821	-1.14	0.2565
Specific Disability					
Cognitive Disabilities	-0.00112	1.0866	821	-0.00	0.9992
Behavioral Disorders	0	-	-	-	-

Table 17. (Continued)

Cognitive Status					
Neurotypical	0.3326	1.2791	700	0.26	0.7949
Cognitively Impaired	0.1046	1.4839	700	0.07	0.9438
Learning Disabilities	0	-	-	-	-
Intervention Characteristics					
Intensity					
Moderator	**Estimate**	**Standard Error**	**DF**	***t* Value**	**Pr > |t|**
Mild	-0.2405	0.7108	657	-0.34	0.7352
Moderate	-0.4541	0.9443	657	-0.48	0.6308
Vigorous	0	-	-	-	-
Duration					
0	-2.6442	1.8844	766	-1.40	0.1610
1	-2.1859	1.8653	766	-1.17	0.2416
4	0	-	-	-	-
Type of Physical Activity					
Rollerskating	0.3829	2.3870	866	0.16	0.8726
Jogging	1.3522	1.3979	866	0.97	0.3337
Walking	-1.3590	2.3325	866	-0.58	0.5603
Chase	0	-	-	-	-
Varied Aerobic	0.6961	1.7387	866	0.40	0.6890
Type of Physical Activity					
Varied Anaerobic	-0.1661	1.7493	866	-0.09	0.9244
Yoga	0	-	-	-	-

Table 17. (Continued)

Agent					
Classroom Teacher	1.9451	1.6194	796	1.20	0.2301
Researcher	-0.2202	1.2883	796	-0.17	0.8643
Video	-0.5342	1.9766	796	-0.27	0.7870
Therapist	-1.2220	2.0837	796	-0.59	0.5577
School Employee	0	-	-	-	-
Classroom	-1.0302	1.2616	816	-0.82	0.4144
School Gym	-0.7330	1.3213	816	-0.55	0.5792
Research Lab	-1.4892	1.4778	816	-1.01	0.3139
School Yard	0	-	-	-	-
Unit					
Individual	0.07669	1.5913	865	0.05	0.9616
Small Group (< 10)	0.9986	1.5997	865	0.62	0.5326
Large Group (> 30)	0	-	-	-	-

*p < 0.005 (statistically significant effect)

Table 18. Results of the 4-level HLM Final Estimation of Fixed Effects for Academic Outcomes

Fixed effect	Coefficient	SE	*T*-Value	Approx. d.f.	*p*-Value
Intercept	1.4981	0.3127	4.79	6	.0030
Tx	2.0122	0.1631	12.34	6	<0.0001

Table 19. Covariance Parameter Estimates

Variance Parameter Estimates				
Parameter	Estimate	SE	Z	*p*-value
Variance in Treatment Effects				
Between Cases	0.02211	0.09978	0.22	0.4123
Variance in Baseline Levels				
Between Cases	0.6168	0.3925	1.57	0.0580
Variance Within Time Series	0.9977	0.1053	9.47	<.0001

Chapter V: Discussion

The current study investigated the effects of physical activity on youths' cognitive, academic, and behavioral outcomes by conducting a meta-analysis of single-case design studies for a 53-year timeframe from 1961 to 2014. Comprehensive search methods were utilized to locate single-case design studies that met inclusion criteria. The primary purpose of this study was to understand the effect that physical activity has on youths' cognitive, academic, and behavioral outcomes by synthesizing the results of single case design studies. The importance of synthesizing these types of designs is highlighted by the fact that usually SCDs are conducted on low-incidence populations and SCDs have been omitted from most literature reviews in this field of study. Another purpose of this study was to conduct a comprehensive analysis of any moderating effects of study, intervention, or participant characteristics to help guide practitioners in the use of physical activity as an intervention to help promote desirable outcomes. This chapter summarizes the results of the current study, relates these findings to existing literature, discusses alternative explanations for the results and limitations of this research, and suggests implications for practice, policy, and for research.

Descriptive Analyses

Although only 15 studies met inclusion criteria, there were 81 time series across all of the studies, giving an adequate sample size to conduct the meta-analysis. It is important to note for future researchers who wish to synthesize the results of studies, that although there may be a fewer number of SCD studies in a body of literature than group design studies, one SCD study

often has multiple time series to synthesize. An often cited limitation of SCDs are that they may not be as reliable as group design studies since the external validity is low, but by synthesizing the results of multiple SCDs this helps to generalize the results (Riley-Tillman & Burns, 2009). It is important to synthesize SCDs for this particular body of literature, as most of the studies were conducted on youth with clinically diagnosable disorders, giving pertinent information regarding the effect of physical activity for lower incidence populations of youth.

The current study used multiple types of search methods to locate studies for the meta-analysis and from analyzing these different methods there are important findings to discuss. It was found that foot-chasing was the most beneficial search method, whereby 62% of the 15 studies located using this method were included in the statistical analyses, a ratio much higher than the other search methods combined. This finding highlights the importance of having multiple methods of searching the literature when conducting a meta-analysis. Another finding gleaned from analyzing the search methods was that four studies were excluded due to the data not being included in the study, which would have added many more than four time series to the meta-analysis. This finding indicates that it is important for researchers to include the individual observations in the study for future synthesis by other researchers.

Study characteristics descriptive findings. There was a large difference in the amount of time series that examined behavioral outcomes (74 time series), compared to academic outcomes (n = 7), and cognitive outcomes (n = 0). Fedewa and Ahn (2011) included group design studies examining both cognitive and academic outcomes. In Fedewa and Ahn's (2011) study, 79% of the 195 ESs were concerning academic outcomes, while the remaining 21% of ESs were concerning cognitive outcomes. Both of the meta-analyses that included SCDs in their

analyses (Allison et al., 1995; Sowa & Meulenbroek, 2012) only included studies that examined the effect of physical activity on youths' behavioral outcomes. This is one way that the current study adds to the existing literature, in that it is the first meta-analysis conducted on SCDs that include both academic and cognitive outcomes.

Another descriptive statistic related to study characteristics to highlight was that there were a variety of behavioral outcomes studied, but for academic outcomes only work completion was examined. In contrast, Erwin and colleagues (2012) and Fedewa and Ahn, (2011) identified several academic outcomes, versus solely work completion. There may have been more variety in group study outcomes than in SCD studies for academic outcomes because many academic outcomes lend themselves to pre and post measures which are not conducive to measures utilized in SCD, which are typically direct observations.

The other study characteristic that stood out was that almost all of the time series were conducted in the United States (91.36%), with only 8.64% conducted in Canada. In previous meta-analyses, the percentage of research conducted outside of the United States was variable ranging from 13% (Fedewa & Ahn, 2011) to 50% (Erwin et al., 2012). In some cases, this information was not reported (Allison et al., 1995; Sowa & Meulenbroek, 2012). Both of the meta-analyses that examined this previously (Fedewa & Ahn, 2011; Erwin et al., 2012) utilized group design studies in their synthesis. It would be interesting to understand if other countries are conducting as many SCDs as the United States or if there is another reason that mainly all of the SCD studies were from the United States.

In sum, the main descriptive discussion points for study characteristics were derived from the finding that footchasing was such an effective method of searching the literature, that missing

data caused exclusion of multiple studies, that the current study is a novel meta-analysis using SCDs because it includes both academic and cognitive outcomes, that only one specific academic outcome was located, and that most of the SCDs were conducted in the United States.

Intervention characteristics descriptive findings. Findings from descriptive analyses of the intervention characteristics indicate that the majority of physical activity interventions were conducted at durations of 0 to 10 or 10 to 30 minute intervals, which is a feasible duration to implement within the school day or at home. Another finding related to intervention characteristics was that the person that implemented the intervention, or agent, was mainly a researcher (61.73%). In future research, it would be wise to assess the feasibility of other adults in the youths' environment conducting the interventions to see if similar effects were seen with for example, a teacher, gym teacher, or parent. However, the moderator analyses for this variable revealed that the agent did not have a moderating effect. Yet there was a low amount of *N* for all categories compared to "researcher". The descriptive analyses also showed that the studies used varied locations (mainly within a school campus) to conduct the physical activity but none of the interventions were conducted at youths' homes. Also, the outcomes were mainly assessed at schools/labs, and community or home-based behavioral outcomes were not present. Further research is needed to see the impact of physical activity on youths' behavior in other common environments. No descriptive information was provided in the pertinent extant meta-analyses concerning duration, agent, or location of intervention (Allison et al., Erwin et al., 2012; Fedewa & Ahn, 2011; Sowa & Meulenbroek, 2012).

The main type of physical activity used in interventions was jogging or varied aerobic activities, which do not require equipment. This is important from a feasibility standpoint for schools although some youth may need supervision to encourage engagement as was done in

some studies conducted on youth with cognitive disabilities (Mays, 2013; Powers, 1992; Rommel 2013). The most similar meta-analysis to the current study also found that the most frequent type of physical activity was jogging (Allison et al., 1995). Jogging and swimming were found to be equally utilized the most in Sowa and Meulenbroek (2012), and among the group design meta-analyses, Fedewa and Ahn (2011) found that aerobic (no details about exact type) was the most frequent type of intervention with physical education close behind, and Erwin et al., (2012) did not provide this information.

Another finding was that most of the interventions were conducted with an individual youth or to a small group, not many were conducted as class-wide interventions. In terms of group size, Allison et al., (1995) did not provide this information and Sowa and Meulenbroek (2012) did detail that a mixture of interventions were being implemented at an individual level and a small group level as they also were in the current study. Among the group design meta-analyses Erwin et al., (2011) did not provide this information, while Fedewa and Ahn (2012) indicated most interventions were implemented at the class-wide level.

In sum, the main descriptive discussion points for intervention characteristics were derived from the findings indicating that low durations of physical activity was most frequent and that further research may be useful concerning the agent of the intervention implementation. Other main points from this data were that the studies collect data mainly in schools and mainly concerning school-based behavioral outcomes versus home or community and that a similar trend has been found in the current study and past studies in that aerobic exercise is a popular form of exercise in this body of literature. Lastly, another important point is that in both the current study and past meta-analyses that included SCDs individual or small groups were the most frequent size of the group for the intervention implementation.

Participant characteristics descriptive findings. Findings from descriptive analyses of the participant characteristics show that a larger percentage of the participants were males (54.32%), while females made up 12.35% of the participants, and the remaining percentage reflects that gender was not provided. As compared to the current study, Allison et al, (1995) and Sowa and Meulenbroek (2012) also found that there were more male than female participants. Of the group design meta-analyses Erwin et al. (2011) did not include these data, and Fedewa and Ahn (2012) reported that studies were conducted with groups of both genders and did not breakout the percentages by type of gender.

Additionally, it was revealed that children with clinically diagnosable disorders made up 92% of the participants, with almost 50% having a cognitive disability. A difference between the current study and the most similar meta-analyes, Allison et al. (1995) and Sowa and Meulenbroek (2012), was that the current study had participants with and without disabilities but these extant meta-analyses included solely participants with disabilities. The group-design meta-analyses did not include these data. In the future it may be helpful to have SCDs with general education students and other students with no clinically diagnosable disorders to see if there is a differential effect of physical activity on youth with diagnosable disorders.

Cognitive status was studied in Fedewa and Ahn (2012) and they stated that 87% of the participants were neurotypically developing, while in the current study about 40% were neurotypically developing. Although moderator analyses were conducted to see if disability status moderated the effect of physical activity on behavioral outcomes, and none were found, there were a low number of participants without disorders used to calculate this effect.

The current study found that an approximate equal percentage of time series (17% on average) were conducted on youth in pre-kindergarten, elementary, and middle school, while 8.64% were in high school and the largest percentage indicated this information was not provided (40.74%). This indicates most of these data should not be generalized to high school students, but to youth in preK, elementary, or middle school. Ethnicity was not provided for 45.68% of the participants and socioeconomic status was not included for any of the participants. It would be useful for future researchers to include these data so that moderator analyses can be conducted. Grade range, ethnicity, and socioeconomic status were not included in the past meta-analyses.

In sum, the main descriptive discussion points for participant characteristics indicated that as in the past most similar meta-analyses there were more male then female participants, although mainly all participants had a clinically diagnosable disorder, some did not, making this the first SCD meta-analysis to include those with and without disorders. Also, a much smaller amount of participants were reported to be neurotypically developing in the current study than in the past group design meta-analysis that included that information, and grade range was not studied in the past, but in the current study the majority of the time series were conducted on participants in pre-k through middle school, and not enough data were included on ethnicity or SES in the current or past meta-analyses.

Inferential Statistics

The results of the current study indicate that physical activity interventions are effective in helping youth increase desirable behaviors and decrease undesirable behaviors as well as to

increase work completion. There was not enough data to calculate the effectiveness of physical activity on youths' cognitive outcomes.

Behavioral outcomes. An effect size of 1.83 was found for the effect of physical activity on youths' behavioral outcomes by synthesizing 74 time series. Allison et al. (1995) conducted a SCD meta-analysis of the effect of physical activity on youth with disruptive behaviors' behavioral outcomes and found a similar effect size of 1.99. A number of reviews in the extant literature indicate that positive relationships exists between physical activity and behavioral outcomes (Gapin et al., 2011; Tomporowski, 2003). Overall, the finding from the current study of the significant effect of physical activity on the behavioral outcomes of youth, mainly with specific clinical diagnoses, was similar to that of the most similar meta-analysis (Allison et al., 1995). The effect size on youths' behavioral outcomes in the extant group design meta-analysis was .33 (Allison et al., 1995) for behavioral outcomes measuring both the acute and chronic effects of physical activity. Sowa & Meulenbroek (2012), found that youth with ASD had a 71.43% increase in social skills from baseline to post intervention data when engaging in individual physical activity. These researchers included group and single-case design studies within the meta-analysis in the analysis using improvement rate as the metric. This effect size value of 1.83 that was found in this dissertation appears much higher than that of what is found when synthesizing group design studies, possibly due to the differences in the type of design and metrics used to calculate the effect size (Hedges et al., 2012). It should be noted that the effect size estimated in this synthesis of single case designs is not equivalent to the the standardized mean difference effect size (Cohen's *d)* used in group design studies, because here the within case variability was used to standardize, while in group studies variation between participatns is used to standardize. Thus the scale for determining the whether an effect size is

small (.2), moderate (.5), or large (.8) in group studies is not applicable. There are statisticians, however, who are working towards having a comparable effect size calculation for SCDs (Hedges, Pustejovsky, & Shadish, 2012; Shadish, Hedges, Pustejovsky, Boyajian, Sullivan, Andrade, & Barrientos, 2014), which may be useful in future work to compare effect sizes from single-case to group designs. Another alternative explanation for the findings may be that SCDs have frequent repeated measures that lend themselves to observing small changes over time, whereas pre-post test designs look for clinically significant changes at two time points. The current study adds information to this body of literature that is similar to that of the previous meta-analyses examining the effect of physical activity on youths' behavioral outcomes. It also provides a study that only included participants between 3-18 in the analyses and participants with and without clinical diagnoses, whereas, Allison et al., (1995) included both adults and children and only youth with clinical diagnoses. Further research is needed, to compare the ES of meta-analyses that use group design studies to calculate the acute effect of physical activity on youths' behavioral outcomes, and not also the chronic effect, to be able to make a more direct comparison of the difference in ES. In the current study, none of the variables had a moderating effect on youths' behavioral outcomes, except the type of SCD. This was the first meta-analysis to conduct a moderator analysis of SCD design. This should be explored in future meta-analyses. Please refer to Table 20 for comparing the moderator analyses for behavioral outcomes to the past meta-analyses. Allison et al. (1995) is the main comparison meta-analyses as Sowa and Meulenbroek (2012) did not conduct moderator analyses, except on the unit, or size of the group the intervention was conducted on.

Of the participant characteristic moderators that were examined in the current study and Allison et al., (1995) there is a consensus that the participant's age and cognitive status do not

make a difference on the effect of physical activity on youths' behavioral outcomes. Also, although the present study is the first to date to conduct moderator analyses on grade range, gender, and specific disability. These variables did not impact the effectiveness of the intervention either. We have not yet had a chance to see if race, SES, or physical fitness level have an impact on the effectiveness of physical activity on youths' behavioral outcomes. All of the included studies in the current meta-analysis and the past meta-analyses that examined the effect of physical activity on behavioral outcomes were conducted on youth with clinically diagnosable disorders (Allison et al., 1995; Sowa and Meulenbroek, 2011). The current study did not find a moderating effect of disability status, but there were a small amount of youth without clinically diagnosable disorders and the extant, most similar, meta-analyses only included youth with clinically diagnosable disorders (Allison et al., 1995; Sowa & Meulenbroek, 2012). Since most of the time series in the current study were conducted with youth with a disability status, and/or cognitive disability, this could be playing a role in the much larger ES as compared to group design meta-analyses.

Table 20. Moderating Effects of Participant Characteristics Between Physical Activity and Youths' Academic, and Behavioral Outcomes Using Extant Quantitative Analyses & Current Study

Type of Characteristic	Specific Characteristic	Academic Outcomes	Behavioral Outcomes
Participant	Grade range	Strongest effects for elementary-aged students, but the ESs for middle and high school level were similar (Fedewa & Ahn, 2011). Grade level did not moderate the effect (Erwin et al., 2012).	Not analyzed (Allison et al., 1995). No difference found in the current study.
	Age range	Not analyzed in the current study or past meta-analyses.	No difference across age groups for single-case design studies. And not examined for group studies (Allison et al., 1995).* No difference found in the current study.

Table 20 (Continued)

Type of Characteristic	Specific Characteristic	Academic Outcomes	Behavioral Outcomes
	Gender	Not analyzed in the current study or past meta-analyses.	Not analyzed (Allison et al., 1995). No difference found in the current study.
	Specific Disability	Not analyzed in the current study or past meta-analyses.	Post hoc observation of the distribution of Ess showed that the four studies with the largest Ess from the group-design studies all defined their participants as hyperactive (Allison et al., 1995). No difference found in the current study.
	Cognitive Status	Ess greater (twice as large) for youth who were cognitively impaired versus youth with typical neurodevelopment (Fedewa & Ahn, 2011). Not analyzed in the current study.	No difference in with developmental delays and those without delays for group design studies or SCD studies (Allison et al., 1995). No difference found in the current study.
	Race/Ethnicity	Not analyzed in the current study or past meta-analyses.	Not analyzed (Allison et al., 1995). Not analyzed in the current study.
	Socioeconomic Status	Not analyzed in the current study or past meta-analyses.	Not analyzed (Allison et al., 1995). Not analyzed in the current study.
	Physical Fitness Level	Not analyzed in the current study or past meta-analyses.	Not analyzed (Allison et al., 1995). Not analyzed in the current study.
Intervention	Duration	No effect for duration (Erwin et al., 2012). Not analyzed in current study.	No effect for duration, for group and single-case design studies (Allison et al., 1995). No effect in the current study.
	Intensity	Not analyzed (Erwin et al., 2012; Fedewa & Ahn, 2011) Not analyzed in current study.	Not analyzed. No effect in the current study
	Type	Aerobic activity resulted in a larger ES than perceptual motor training and physical education (Fedewa & Ahn, 2011). Not analyzed in current study or Erwin et al., (2012)	Non-aerobic exercise had a larger ES than aerobic for group design studies and single-case design studies. However, there were only two studies that used non-aerobic exercise for group design studies. (Allison et al., 1995). No effect in the current study.
	Agent	No significant difference between who administered intervention (Fedewa & Ahn, 2011). Not analyzed in current study, or in Erwin et al., (2012)	Not analyzed. No effect in the current study.

Table 20 (Continued)

Type of Characteristic	Specific Characteristic	Academic Outcomes	Behavioral Outcomes
	Location	Not analyzed in (Erwin et al., 2012 ;Fedewa & Ahn, 2011) Not analyzed in current study.	Not analyzed. No effect in the current study.
	Unit	Small group interventions (less than 10) had the largest effect then medium groups, followed by large groups or whole classes (Fedewa & Ahn, 2011); In studies that used mixed-gender groups versus single gender, the former had larger ESs (Fedewa & Ahn, 2011). Not analyzed in current study or Erwin et al., (2012)	Individual interventions had a larger effect than group (2 or more participants) for youth with ASD specifically on social outcomes (Sowa & Meulenbroek, 2012). No effect in the current study.
Study	Published/Unpublished	No difference (Erwin et al., 2012; Fedewa & Ahn, 2011). Not analyzed in the current study.	No difference in group design studies (Allison et al., 1995). For SCD unpublished studies had a significantly larger effect size than published studies (Allison et al., 1995).No effect in the current study.
	Outcome Type Measured	Found that effects were significant across a variety of different outcomes (math achievement highest, IQ, reading achievement, total achievement, other, grade point average, spelling/vocabulary, and science, respectively (Fedewa & Ahn, 2011). Not analyzed current	Not analyzed in Allison et al., (1995) Not analyzed in the current study.
	Study Country	No difference found between United States versus non-U.S. (Fedewa & Ahn, 2011); Study location moderated the effect-Europe had a larger effect (Erwin et al., 2012). Not analyzed in current study.	Not analyzed in Allison et al., (199) Not effect found in the current study.

Table 20 (Continued)

Type of Characteristic	Specific Characteristic	Academic Outcomes	Behavioral Outcomes
	Specific Measures	Not analyzed in (Erwin et al., 2012; Fedewa & Ahn, 2011) Not analyzed in current study.	Not analyzed in Allison et al., (199) Not effect found in the current study.

Note. * Allison et al., (1995) did separate analyses for group design studies versus single-case design studies, therefore everywhere there is a citation of this study it is indicated which type of study design found a moderating effect. For all of the other cited studies, the analyses did not separate based on study design.

In terms of the moderating effects of intervention characteristics, although this was the first analyses on these specific potential moderatoring variables, including intensity, agent, and location, they do not seem to make a difference in the effectiveness of the intervention on youths' behavioral outcomes. However, most of the interventions in the current study were conducted by researchers as the agent, versus natural adults in the youths' lives. The researchers were able to exert control over other variables and knew exactly how to conduct the interventions, whereas in practice, adults administering the intervention may not be able to conduct the interventions with such fidelity and control for other variables. Future research should explore the results if teachers, parents, other adults in youths' lives were administering the intervention. Although no moderating effect was found for agent, there was still a low amount of *N* for the other agent categories. In addition, none of the studies took measures on intervention fidelity, thus this is unknown and could have influenced the observed results of the meta-analysis. Social validity and intervention fidelity measures are recommended to be taken in studies in the future with using adults that are naturally involved in the youths' lives as the intervention agents. A consensus has been met with the current study and Allison et al., (1995) that the duration of the exercise does not seem to matter for the effectiveness of the intervention. It is hopeful that no moderating effects were found for the different durations of 0 to 10 or 10 to

30 minutes, and no studies were located with physical activity interventions lasting for more than 30 minutes, since shorter timeframes for physical activity may be more feasible to fit into a youths' school or home schedule. The results suggest the effect can be seen using these shorter duration interventions and considering that a large percent, 49.38%, of the participants studied in the current study had cognitive disabilities, the shorter duration may be more feasible for staffing help during the intervention.

Further research is needed to come to a consensus concerning the moderating effect of the type of exercise, as well as the unit of the intervention implementation. In the current study the type of exercise was not found to make a difference, but anaerobic exercise was found to have a larger effect size then aerobic exercise in Allison et al., (1995). Also, in the current study no moderating effect was found for the unit but in Sowa and Meulenbroek (2012), a moderating effect for unit was found. These researchers found that physical activity had a significantly larger effect for youth with ASD if the intervention was conducted at an individual level versus in a group setting.

Almost all of the study characteristic moderators that were analyzed in the current study were not examined in the past meta-analyses, including type of SCD, study country, and specific measures. One variable that was researched in a past meta-analysis and the current study was publication status and a consensus has not been met. The current study found no effect for publication status, while Allison et al. (1995) found that unpublished studies had a signficantly larger ES than published studies. The new addition to the examination of study characteristic moderators was that the current study examined and found a moderating effect for the type of SCD. This indicates that there may be a difference in the effectiveness of the physical activity

intervention on youths' behavioral outcomes depending on the type of SCD utilized. Although the moderator analysis provided a comprehensive list of variables, there are certainly potential moderators that have not been included in this analysis. For example, is there a moderating effect of indoor versus outdoor physical activity, whether the physical activity was conducted in such a way that collaborated with other youth or was it competitive or neither, or is there a moderating effect if physical activity embeds academics into the activity itself (Best, 2010)?

In sum, we have learned more about the moderating effects of variables on the effectiveness of physical activity on youths' behavioral outcomes when including the current study results to past meta-analyses results. We have learned that some moderators seem to be consistently showing that they do not moderate the effect, including age, cognitive status, and duration. We have learned that we still do not know if some variables moderate the effect including, type of physical activity, unit of participants in the intervention, and publication status. We have also learned that some variables have yet to be analyzed including, race, SES, and physical fitness level. Due to the first moderator analysis being conducted in the current study, new information has been learned as well. This includes an understanding that the following variables do not moderate the effect: grade range, gender, specific disability, intensity, agent, location, study country, and specific measures. Also, a new analysis was conducted in the current study, in which it was found that the type of SCD does moderate the effect of physical activity on youths' behavioral outcomes, specifically that ABAB designs have a larger effect than alternating treatments.

Academic outcomes. In the current study the effect of physical activity on youths' academic outcomes was found to be 2.01, and all 7 time series included in calculating this effect

size studied only one specific dependent variable, work completion. This research was the first meta-analyses to include SCDs that examined the effect of physical activity on youths' academic outcomes. All of the time series included in the current meta-analysis in examination of the effect of physical activity on youths' academic outcomes were conducted on youth with clinically diagnosable disorders. It is possible that the large effect size could be attributed to the possibility of a moderating effect. This ES is hard to directly compare to past meta-analyses since the past meta-analyses used group design studies only and the statistic used to calculate effect sizes in SCDs is not comparable to Cohen's *d* used in group design studies. Erwin et al. (2012) studied the effect of classroom-based physical activity on academic outcomes, and included four group-design studies with a mean effect size of .67. Fedewa and Ahn (2011) included 59 studies and the effect sizes ranged from 0.44 for math achievement to .22 for spelling/vocabulary. There were no analyses conducted for work completion. In support of the current research findings, all of the past reviews in the extant literature indicate that positive relationships exist between physical activity and academic outcomes (Strong et al., 2005; Tomporowski et al., 2008; Tomporowski, 2003). This is an important area for researchers to continue to develop. A possible way to increase the amount of SCD studies that study academic outcomes is to utilize measures that show small changes over time, such as Curriculum Based Measures (CBM), which are sensitive to small changes. Due to a low amount of data, the analyses to examine the moderating effects of the various study, intervention, and participant characteristics were not able to be conducted.

In conclusion, the majority of researchers conducting meta-analyses examining the effect of physical activity on youths' cognitive, academic, and behavioral outcomes have excluded single-case design research from the data analyses. Based on the findings from the current study

indicating a large effect size for behavioral outcomes and work completion, it is important to include SCDs in the synthesis of the literature. This helps paint an accurate representation of the effect size of the intervention for particular populations, considering the majority of these studies were conducted on youth with clinically diagnosable disorders. It is important to consider whether the effect sizes found in the meta-analysis coincide with those observed through visual analysis of the individual studies, and upon observation, the effect sizes do seem to match. One would expect to visually observe a large change in level between data in baseline and physical activity conditions in most graphs from the included studies examining behavioral outcomes, to represent the effect size found in this meta-analysis of 1.83. For example, upon visual analysis of the graphs in the study by Celiberti, Kelly, Harris, & Handleman (1997), the graphs show a large change in level between data in the baseline versus condition phases. The differences in moderating effects and the lack of data to conduct some moderator analyses is important to highlight so that future researchers continue to collect this data to help better inform researchers and practitioners of these effects.

Generalizability of Conclusions

The findings in the current study can be generalized to youth with clinical disorders such as ASD, behavioral disorders, and cognitive disabilities in mainly pre-kindergarten, elementary and middle school. High school aged youth were a smaller percentage of the sample population so caution in interpreting the effect size for this population is suggested. Furthermore, most of the participants were white (40.74%, 13.58% black) and male (54.32%), whereas 12.35% were female. There was a high amount of youth with cognitive impairments as well as those that were

neurotypically developing. Yet most participants had clinically diagnosed disorders but approximately only half had cognitive impairments.

The findings in regards to intervention characteristics should be generalized to physical activity conducted at schools, utilizing mainly aerobic, jogging exercises, and conducted with researchers as the intervention agent. Furthermore, the results are generalizable to a wide variety of behavioral dependent variables but in terms of academic outcomes, only to work completion.

Limitations

There are several limitations with the current study. The studies that were included in the meta-analysis did not conduct treatment integrity checks on interventions. This is a limitation because without these data it is unknown if the intervention was carried out how it was planned, which would have controlled for extraneous variables. Also, in the included studies there were no studies that included an attention condition to see if the results were attributable to the physical activity intervention or to the youth receiving additional adult attention. Furthermore, measures were not taken on the social validity of the interventions. These are limitations because data were not collected to see if the intervention was something that youth found enjoyable and therefore would be motivated to participate in. Also measures were not taken on the social validity of the intervention for the agents of change. These are important data to collect because information would be gathered to analyze if the interventions were feasible and viewed as effective by the intervention agents. A limitation of the available literature was the lack of located studies on the effect of physical activity on youths' academic outcomes, which limited the results to specifically understanding physical activities' effect on work completion. Additionally, no moderator analyses could be conducted on the effect of physical

activity on youths' academic outcomes, nor any analyses on physical activities' effect on cognitive outcomes. Another limitation of the study is that the results are generalizable only to the particular settings, participants, and interventions that were examined in the meta-analysis. Furthermore, only the first phase change and this may have limited the results, as they did not capture whether the intervention had a differential effect further along in time. An additional limitation is that the search methods may not have located all of the feasible studies and there were 9 studies that were excluded for various reasons, although they met all of the inclusion criteria. Publication bias is a commonly cited limitation and there were 72.84% published versus unpublished, however, moderating effects of publication status were not found. A commonly-cited limitation of conducting a meta-analysis is that the results of the study will be only as good as the quality of the results of the individual studies (i.e., unreliable usage of measures or flaws in the design) (Littell, Corcoran, & Pillai, 2008). From a review of the individual studies the quality of the studies seems to be good but the quality of the studies were not analyzed with a specific quality indicator rubric. Additionally, there are chances of data entry and calculation errors but interrater reliability checks were conducted at various stages of the data collection, extraction, and coding methods with acceptable percentages of agreement.

Implications and Interpretation for Theory, Policy, or Practice

In this section the implications and interpretation of the results will be discussed for theory, policy, and practice. In terms of implications for theory, this study did attempt to examine the moderators that are included in Tomporowski, Lambourne, and Okumura's (2011) working model of possible mediators and moderators that could influence the relationship of physical activity on youths' cognitive and academic outcomes. The three proposed moderators in

this model include: age, SES, and gender. In the current study, there were no studies that examined the cognitive outcomes of youth engaging in physical activity and moderator analyses were not able to be conducted for physical activitys' effect on youths' academic outcomes (work completion) due to lack of data. To add to this working model, future research could test these proposed mediators and moderators through research designed specifically to test this model or researchers in this field could be encouraged to collect this data for later synthesis.

The results of this meta-analysis provides evidence for policy-makers, to add to the evidence-base to help stakeholders advocate to make or keep policies that protect youth with clinically diagnosable disorders to the right to physical activity during the school day to help impact academic success.. This meta-analysis provides information that even 0-10 minutes or 10-30 minutes of physical activity can have a positive effect on certain youths' academic (work completion) and behavioral outcomes. This information is important for educators to know so that physical activity can be fit into the school day at other times than just during physical education class as a way to help certain youth perform behaviorally and academically at school. Physical activity at these dosages, per the research by the CDC (USDHSS, 2010) is not enough time to feel the effect of physical activity on health, but may help with certain youths' behavior at school. It is also important to recognize that in the current study few moderators were able to be tested or found to have a significant impact. The implication for this is that until further research is done, policy makers should be cautious about suggesting that this type of intervention is only beneficial for specific youth or under specific conditions.

Guidelines for Future Research

Many guidelines for future research have already been discussed throughout the discussion. To review, these suggestions include for researchers to include SCDs in meta-analyses, to use multiple methods of searching the literature, and to include the individual observation data in the study for future synthesis. Additionally, further research using SCDs could be conducted on the other behavioral outcomes, for many different academic outcomes, as well as for cognitive outcomes. Furthermore, it was suggested that future researchers assess the feasibility of delivering the intervention using naturally occurring adults in youths' lives versus researchers, and that there are more SCDs conducted with general education students and other students with no clinically diagnosable disorders. In addition it is important to have a group design meta-analyses that examines only the acute effect of physical activity and not also the chronic effects in the same analysis.

It seems that SCDs may not lend themselves to research that studies the acute effects of physical activity on cognitive outcomes, possibly due to the types of cognitive measures typically used. The fact that no studies were located that examined the effect of physical activity on cognitive outcomes indicates an important area for researchers to focus on, specifically, finding or developing cognitive measures that are valid for use in SCD research. The same can be said for studying the acute effect of physical activity on youths' academic outcomes, in that more research may occur if research uses measures such as Curriculum Based Measures (CBM). Also, it would be beneficial for researchers to continue to collect moderator information related to Tomporowski, Lambourne, and Okumura's (2011) working model as well as on the comprehensive list of study, intervention, and participant characteristics laid out in this study,

even if the moderator analyses are not conducted in the individual studies, the data could later be synthesized. Lastly, future research could seek to elucidate why such differences in ESs were indicated in meta-analyses using group designs compared to meta-analyses using SCDs.

Conclusion

The results of this study have important implications for specific populations of youth and those who work with or care for these youth. Also the results are important for practitioners to advocate for the use of physical activity as a way to help promote appropriate behaviors and completion of academic work within schools. It is important for more SCDs to be conducted to study the impact of physical activity on academic and cognitive outcomes to further understand if there is such a large difference in effect sizes among meta-analyses using group design studies versus SCD studies. Also, it may be beneficial to have more SCDs conducted on youth examining the impact of physical activity on varying behaviors, academic outcomes, and cognitive outcomes. Also, all studies in this body of literature should collect data on potential moderating variables. This is the first meta-analyses to include both behavioral and academic outcomes of SCDs in the same study, utilizing only SCDs with youth between the ages of 3-18 in the analyses, and that includes SCDs with both youth with and without clinically diagnosable disorders. The effect sizes of the current study are very promising to indicate the evidence-base of utilizing physical activity for youths' behavioral outcomes at school, as well as, work completion of particular populations of youth.

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