

RESEARCH ARTICLE

Integrating Physical Activity into Preschool Classroom Academic Lessons Promotes Daily Physical Activity and Improves Literacy

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Poor early literacy skills and obesity in preschool children have been associated with poor academic achievement later in life. Limited evidence suggests an association of physical activity with improving literacy and decreasing obesity in older children (Carlson et al., 2008). However, the effects of increasing physical activity on literacy skills in preschool children are not known. This article describes the impact of academic lessons taught through physical activity on literacy skills of preschool students enrolled in Head Start. The results showed that increasing physical activity in the preschool classroom led to reductions in sedentary behavior during free play and in body weight, and improvements in literacy compared to non-exercising classrooms. Therefore, physical activity academic lessons are cost effective, require minimal teacher preparation, and result in improved academic scores and lower body weight.

Keywords: literacy, preschool curriculum, childcare/daycare, poverty, Ethnic minorities

Due to the No Child Left Behind Act, many preschool administrators and teachers have cited increased pressure from K-12 administrators and legislators to increase the focus on standardized testing in preschool which has limited the focus on a broader academic development and health of children, in particular the obesity of children (Conley & Hinchman, 2004). Increased physical activity offers a potential intervention to address both issues. However, concern over meeting academic achievement goals has resulted in the reduction or elimination of physical activity in many preschools.

African American preschool children ages 3-5 years are at an increased risk for poor literacy development, often arriving at school with poorly developed vocabularies (Hart & Risley, 1995; Rush, 1999), which make learning to read more difficult. Obesity has been linked to deficits in early literacy skills in preschool children, in particular African American children (Haas et al., 2003; Sherry et al., 2004) who have a higher prevalence rate for childhood weight problems (Active Start: A Statement of Physical Activity Guidelines for Children Birth to Five Years, 2008; Haas et al., 2003; Sherry et al., 2004). Engagement in physical activity has been cited as a critical

intervention in preventing obesity and improving academic achievement (Tomprowski, Davis, Miller, & Naglieri, 2008). To this end, there is an urgent need for developing effective ways to increase physical activity in preschool children.

Despite the association between physical activity and improved cognitive function, the majority of published research that has examined the effects of physical activity on children's cognitive function in relation to academic achievement as an outcome measure has been conducted primarily with school-age children (Castelli, Hillman, Buck, & Erwin, 2007; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001; Keays & Allison, 1995). To our knowledge there has been little to no research completed with preschool age children (3 – 5yrs of age). Evidence suggests the importance of developing physical activity habits early in life. Since early childhood is both the most critical and most vulnerable period in a child's development (Conlon, 2002), there is additional need for research with this population.

Teachers and parents have assumed that preschool children are very active and engage in sufficient physical activity (Benham-Deal, 1993a; Sallis, Patterson, McKenzie, & Nader, 1988). A systematic review by Tucker (Tucker, 2008) examined a total of 39 studies (published between 1986 – 2007) from seven countries (United States, Scotland, Finland, Australia, Chile, Estonia, Belgium) to establish an accurate reflection of the physical activity levels of preschool children. Nearly half of the studies included in the review reported less than 60min/day of physical activity; therefore these children were insufficiently active according to NASPE guidelines (Active Start: A Statement of Physical Activity Guidelines for Children Birth to Five Years, 2008; Tucker, 2008). With only 54% of preschool children in this review found to be sufficiently physically active within this age group (Ogden et al., 2006); additional efforts are necessary to promote healthy activities in the preschool setting.

The field of Early Childhood Education and Head Start in particular, has placed an increased emphasis on program improvement and accountability based on children's outcomes. One of the outcomes targeted by Head Start programs includes development in the areas of literacy and language, which are critical to academic success later in life (Walker, Greenwood, Hart, & Carta, 1994). Therefore, the combination of these factors indicates research is needed that addresses the impact of physical activity on children's physical health and mental function (Tomprowski, Davis, Miller, & Naglieri, 2008). The effect of regular physical activity on improving development of early literacy skills in preschool children, a critical period in children's development, is not known. Physical activity has been shown to improve literacy skills in children ages 6-18 years (Tomprowski, Davis, Miller, & Naglieri, 2008). However, the effects of increases in physical activity in African American children age 3-5years are not known. Integrating physical activity into Head Start preschool classrooms academic lessons offers an innovative approach to increasing physical activity during the school day without decreasing the time devoted to academics. Therefore, the purpose of this study was to determine the impact of academic lessons taught through physical activity on the early literacy of preschool students enrolled in Head Start. We hypothesized that students in the classrooms that receive the academic lessons taught through physical activity would have significantly greater increases in early literacy from baseline to three months and it would be maintained at six months compared to students in control classrooms that did not

participate in the physical activity lessons. Specific research questions included the following: 1) did children in the intervention classroom decrease their body mass index (a reliable measure of body fatness) compared to the control classrooms, 2) did child literacy skills increase in the intervention classrooms as compared to child literacy skills in the control classrooms.

METHOD

Participants

Children. There were a total of fifty-four (Intervention, n=24, Control, n=30) African American preschool children (mean±SE, age 3.9±0.1y, body mass index 16.8±0.2 kg/m²) from a low socioeconomic urban Head Start program that participated in the six-month study (see Table 1 for participant characteristics). Approximately two-thirds of the children were either overweight (Body Mass Index ≥85-94th percentile for age, Intervention, n=10, Control, n=12) or obese (Body Mass Index ≥95th percentile for age, Intervention, n=6, Control, n=8) with the remaining normal weight (Intervention, n=8, Control, n=10). Over 99% of families enrolled in the Head Start program were African American and >95% of families were categorized as living below the poverty line. Prior to the start of the study, parents signed an informed assent for their children to participate. The study was approved by the researchers' university Internal Review Board.

TABLE 1
Baseline Participant Characteristics

	Physical activity	Control
Age (yrs)	3.9±0.1y	3.9±0.1y
Weight (kg)	18.4 ± 2.1	17.7 ± 1.9
Height (cm)	105.4 ± 2.2	104.1 ± 1.8
BMI (kg/m ²)	16.8 ± 1.4	16.7 ± 1.0
Alliteration (number of letters sounds correctly identified/two min)	0.5 ± 0.2	0.5 ± 0.2
Rhyming (number of rhymes correctly identified/two min)	0.7 ± 0.3	0.7 ± 0.2
Picture naming (number of pictures named correctly/min)	15.0 ± 5.9	15.0 ± 5.3

Note. Values are mean ± SEM. No difference between groups

Teachers. Each classroom was staffed with two teachers (one lead teacher and one assistant teacher). There were a total of eight teachers (four lead and four assistants), all of them female. There was a total of two lead and two assistant teachers who were African American. One lead and one assistant teacher who were African American were in the intervention classrooms and one lead and one assistant teacher who were African

American were in the control classrooms. There was a total of two lead and two assistant teachers who were Caucasian. There was one lead and one assistant teacher who were Caucasian in the intervention classroom and one lead and one assistant teacher who were Caucasian in the control classrooms. The four lead teachers had a Bachelors degree in early education with an average of 15 years of experience. The four assistant teachers had associate degrees in early education with an average of 10 years experience. The teachers signed an informed consent form prior to participation.

Setting

Head Start preschools. Within the Head Start program, two sites totaling 4 classrooms participated in the study. The preschool sites were in the same urban city (just 1 mile apart) and managed through a partnership with a local university. Teachers followed the Head Start curriculum, teacher implementation and time spent on curriculum were identical in both preschools as measured by direct observation and teacher report. All available resources such as technology, educational material, teacher training, were identical across classrooms. Both sites followed the same curriculum and were expected to monitor child progress toward outcomes as monitored by the Head Start Child Development and Early Learning Framework (2010).

Study Design

A two group, quasi-experimental design with one preschool site participating in the physical activity intervention (1 preschool, 2 classrooms, n=24 F, n=10, M, n=14) and a second site participating as the control site (1 preschool, 2 classrooms, n=30, F, n=13 F, M, n=17) was used. Students were assigned to condition based on the site they attended.

During the first three months, a member of the research team performed daily observations, feedback and support to ensure the physical activity lessons were being administered correctly and to monitor compliance. During months four through six there was no contact between the investigators and the teachers. The limited contact was done to evaluate if there was a maintenance effect in which the physical activity lessons continued to be used by teachers without ongoing support and feedback by the research team.

Training. Both the lead and assistant teacher in each classroom were part of the training session and took part in the leading of the physical activity program. Every effort was made through initial training and ongoing communication to remind teachers not to discuss the study between each preschool site.

Training of research assistants. Research assistants were trained to support the classroom teachers in the design and delivery of the exercise program, in troubleshooting, and problem-solving strategies as discussed in the teacher training section under procedures. Research assistants who conducted testing were trained to collect valid and reliable data and had to obtain intra-class correlations of 0.80 or greater

to be certified to administer each measure. At baseline, three, and six months body weight (intraclass correlations, ICC = 0.99), height (ICC=0.99), and early literacy skills (alliterations, ICC = 0.95, rhyming, ICC = 0.96) were obtained.

Measurement Tools

Body mass/BMI. Weight was assessed using a portable digital scale accurate to ± 0.1 kg (Befour Inc., Model #PS6600, Saukville, WI). Height was assessed using a portable stadiometer (Model PE-WM-60-84, Perspective Enterprises, Portage, MI). BMI was calculated as weight (kg)/height (m^2).

Early literacy skills. Early literacy and language were measured using the Early Literacy Individual Growth and Development Indicators (IGDI - Research and development of individual growth and development indicators for children between birth and age eight; Tech. Rep. No. 4, 1998). Three Individual Growth and Development Indicators (IGDIs) are commonly used as indicators of children's language and literacy development in preschool programs. These three measures, *Picture Naming* assessment of expressive language development, *Rhyming* and *Alliteration* assessment of phonological analysis, were each developed by researchers at the University of Minnesota under the auspices of the Early Childhood Research Institute on Measuring Growth and Development (Research and development of individual growth and development indicators for children between birth and age eight; Tech. Rep. No. 4, 1998).

Picture naming individual growth and development indicator (PN IGDI). Administration of the PN IGDI is completed by presenting children with color pictures (photographs or line drawings) of objects found in natural environments, including home (e.g., cake, sink), classroom (e.g., glue, book) and community (e.g., rabbit, train). The children were told to name pictures as quickly as possible. The number of pictures named correctly in one minute was the child's score. If the child did not respond to any given picture within three seconds, the examiner gave a prompt by saying, "What's that?" or "Do you know what this is?" and allowed the child an additional two seconds to respond before moving to the next card. Items were selected from a set of approximately 120 pictured objects. Examiners were instructed to use four standard sample cards (to demonstrate the task and confirm the child's understanding of the task), and then to administer a randomly selected set of one to 50 cards.

Rhyming individual growth and development indicator (RH IGDI). Administration of the RH IGDI is completed by presenting a child with a series of cards. Each card shows four pictures: at the top is a picture depicting the stimulus word (e.g., bees) and under the stimulus picture is a row of three other pictures (e.g., house, pants, cheese) with one correct and two incorrect responses. For each card the examiner points to and says the name of each picture and tells the child to, "Point to the picture that sounds the same as the top picture." After demonstration (two standard cards)

and practice items (four randomly selected cards), the examiner shows a random selection of cards for two minutes. A child's score is the number of correctly-identified rhymes in two minutes.

Alliteration individual growth and development indicator (AL IGDI). Alliteration is similar to the other two IGDI's in that it uses stimulus cards and the child's score is the number correct during a timed administration. The AL IGDI cards depict four pictures: at the top is a picture depicting the stimulus word (e.g., cake) and under the stimulus picture is a row of three other pictures (e.g., cat, sink, bear) with one correct and two incorrect responses. The child is told to, "Look at the pictures and find the ones that start with the same sound." For each card the examiner names all the pictures for the child. After demonstration (two standard cards) and practice items (four randomly selected cards), the examiner showed a random selection of cards for two minutes, counting the number correct in that time as the child's score.

System for Observing Fitness Instruction Time. (SOFIT; McKenzie, Sallis, & Nader, 1992) provides a measure of student activity levels, lesson context, and teacher behavior. This validated tool was developed to assess the quality of physical activity instruction. Research assistants were trained to make direct observations of physical activity levels within the classroom and learn how to record them uniformly. Using the SOFIT, a time-moment sampling technique (McKenzie et al., 1992), research assistants practiced recording the physical activity intensity level of students in several classrooms, using a Likert-type scale (e.g. 1 = lying down, 2 = sitting, 3 = standing, 4 = walking, 5 = jogging/running). SOFIT data correlates significantly with average heart rate ($r=.61$) and TriTrac monitoring (a small device that objectively measures physical activity patterns, $r=.61$) (Pope, Coleman, Gonzalez, & Heath, 2000).

Inter-Rater Reliability. To calculate inter-rater reliability for the above-mentioned measures, two observers, independently but simultaneously, observed for approximately 30% of the classroom sessions. Interobserver reliability estimates were calculated by dividing the number of agreements by the number of agreements plus disagreements, and multiplying the total by 100%. Interobserver agreement across sessions was 88%. Ratings were compared across research assistants for reliability and percentage agreement was calculated. To control drift across time, reliability testing was conducted every three months.

Teacher survey of program. To gain additional information that would be helpful in guiding the overall design and implementation of the program for future studies, we asked teachers to complete a 10-item survey, which we adapted from the Child and Adolescent Trial for Cardiovascular Health (CATCH) Physical Education Observation Form (McKenzie et al., 1997), at the end of the study.

Statistical Analyses

Body fat (research question one). Overweight and obesity were determined using body mass index (BMI). An adjusted t-test (Donner & Klar, 2000), which accounts for the intraclass correlation, was used to assess change in BMI from baseline to six months. Change in BMI was also analyzed longitudinally, using a linear mixed model with an autoregressive type 1 covariance structure for the longitudinal measurements over time and compound symmetric covariance structure for the intraclass correlation within schools, also adjusting for gender.

Early literacy skills (research question two). Child literacy skills were assessed using three measures of early literacy skills. Picture naming assessment of expressive language development, rhyming assessment of phonological awareness and alliteration assessment of phonological awareness were analyzed using an adjusted t-test (Donner & Klar, 2000), which accounted for the intraclass correlation, to assess change in these variables from baseline to six months. Change in picture naming, rhyming and alliteration was also analyzed longitudinally, using a linear mixed model with an autoregressive type 1 covariance structure for the longitudinal measurements over time adjusting for gender (Donner & Klar, 2000).

Fidelity of teacher implementation. Fidelity of teacher implementation of the physical activity lessons was measured using the SOFIT observation tool. SOFIT data were compared between the intervention and control classrooms using a mixed linear model adjusting for age and sex. The effects of teacher modeling on SOFIT scores were analyzed using ANOVA.

Teacher satisfaction. Teacher satisfaction was measured through a teacher survey. Data from the teacher survey were summarized descriptively, using means and standard deviations for continuous data and frequencies and percentages for categorical data. All quantitative analyses were done using SAS version 9.1 (SAS Institute, Inc., Cary, NC, USA). The alpha level was set at 0.05 for all analyses.

PROCEDURES

Baseline

Body mass/BMI. Body mass was assessed at baseline, three and six months, between the hours of 7:00 and 10:00 AM on the same day for both groups.

Individual growth and development indicators administration. The preschool IGDI assessment data were collected on three occasions using the methods described above for IGDI; at baseline and at months three and at six on all children enrolled in the intervention and control sites so that the data could be compared across groups.

Interobserver agreement. Interobserver agreement for the preschool IGDI was conducted for approximately 25% of administration sessions. While one person administered and scored the assessment, an additional observer scored the assessment, independently but simultaneously. Interobserver reliability estimates were calculated by dividing the number of agreements by the number of agreements plus disagreements, and multiplying the total by 100%. Interobserver agreement across sessions was 92% (range, 87-95%) for picture naming, 91% (range, 88-93%) for rhyming, and 93% (range, 90-96%) for alliteration.

Classroom observations using SOFIT. Following completion of baseline BMI and IGDI assessments, direct observations of individual classrooms were initiated to establish baseline classroom activity levels. SOFIT data were collected for all participating classrooms during the week prior to implementation of the physical activity program.

Interobserver agreement. Interobserver agreement for the SOFIT was conducted for approximately 30% of administration sessions. While one person administered and scored the assessment, an additional observer scored the assessment, independently but simultaneously. Interobserver reliability estimates were calculated by dividing the number of agreements by the number of agreements plus disagreements, and multiplying the total by 100%. Interobserver agreement across sessions was 90% (range, 87-93%).

Intervention

Physical activity program. The carefully designed physical activity program was designed by researchers with expertise in early childhood development and physical activity along with teachers and administrators at the Head Start program. To increase the likelihood of dissemination in other Head Start centers, the activities were carefully designed to be easily administered by classroom teachers while being fun and engaging for preschool children.

The program was designed to keep the children moving in moderate physical activity for 15 minutes two times per day (30 minutes daily). Thirty minutes was chosen to meet part of the recommended 60 minutes per day of moderate intensity physical activity (Active Start, 2008). The program was administered inside or outside of the classroom, to music or without music. The goal was to make it fun and engaging for both the teachers and students. Teachers were free to choose the time each morning and afternoon that best fit into the day's schedule but each teacher was required to administer a morning and afternoon session at a time when it is likely that most if not all students were in attendance (e.g. after breakfast in the AM but before children are picked-up by parents in PM). During the first three months daily direct observation by the investigators was used to ensure that the physical activity lessons were administered appropriately. During months four through six (maintenance) teachers in the intervention group were required to complete a daily activity log. To complete the log, teachers indicated in which physical activity lesson was used, the time of day they performed the activity lesson, the total number of minutes that each activity lasted, and estimate the intensity level at which

they believed the children were performing (i.e., light, moderate or high intensity levels). During months four through six an email was sent each week to the intervention teachers to remind them to complete the activity logs. However, no other support or training was given to the teachers during months four through six.

A variety of literacy lessons were used in the areas of picture naming assessment of expressive language development, rhyming and alliteration assessment of phonological analysis. For example, a goal of a rhyming lesson was for children to find the rhymes within a particular poem or short story. The activity was designed to help children understand and identify rhyming words. During the lesson children would march in place while the teacher repeated several lines of a poem and the child identified the words that rhymed. Depending on the words that rhymed, the children would either act out the words or perform a certain number of jumping jacks (or other movement) before moving on to the next two lines of the poem and repeating the sequence throughout the poem. A detailed example of an activity lesson is found in Table 2. While these concepts were covered at both the intervention and control site, the primary difference was that the intervention site integrated these lessons into a physical activity rather than taught solely through large group time, reading, or other classroom activities.

TABLE 2.

Example of Physical Activity Lesson Rhyming Awareness

Goal: In this lesson children are to find the rhymes. This activity helps children understand and identify rhyming words.

Materials needed: Select a rhyming poem from the packet of poems. (E.g. Ten Little Bluebirds)

Instruction: When reading or reciting rhymes and rhyming stories, pause to identify words that rhyme. Use the word *rhyme* to describe the common ending sounds.

Activity Lesson: Children should march in place throughout the lesson. Begin by reciting the poem "Ten Little Bluebirds" two sentences at a time. After the first two sentences, identify the rhyming words "pine" and "nine" by saying "Do you know what? Pine and nine sound alike. They both end with the sound -ine. Pine and nine rhyme!" The children should then perform "nine" jumping jacks while counting out loud. Once completed with the nine jumping jacks the children should resume marching in place. Repeat for the remaining poem but use other activities such as touching toes, move arms up and down, jogging around the circle carpet. Repeat a second time so the children become familiar with the poem.

Advanced Lesson: In future lessons as the children become familiar with the poems ask the children to identify the rhymes as you read. For example, when reciting the poem "Ten Little Bluebirds," after the first two sentences, ask the children to identify the rhyming words. "I think there were two words that rhyme; can anyone tell me which words rhyme?" The children should indicate they know the answer by jumping up and down in place. Repeat for the remaining lines.

Maintenance. During the first three months of the study there was daily direct observation of the physical activity lessons, feedback and support by the investigators to the teachers implementing the physical activity lessons. This timeframe allowed teachers several months to incorporate physical activity into their regular lessons with the help of staff and to gain a sense of mastery with presenting active lessons. During months four through six there was no direct contact between the teachers and the investigators. The limited contact was designed to evaluate if there was a maintenance effect in which the physical activity lessons continued to be used by teachers without ongoing support and feedback by the research team.

Teacher training. Training was provided to classroom teachers and assistants in each of the two intervention classrooms at a full-day in-service at the beginning of the school year. The goal of the in-service training was to develop competency and strategies to deliver two, 15-minute periods of moderate to vigorous intensity, physically active lessons per day. Additionally, during the first three months, a member of the research team was available in each classroom each day to observe and assist with the administering of the physical activity program. The first two weeks of the program was where most of the assistance in implementing the program occurred as the teachers learned the physical activity lessons. The primary area where research assistants helped the teachers in implementing the program was in knowing how to do a particular activity movement such as jumping jacks or toe touches. After the technique was demonstrated the research assistant would evaluate how the teacher performed the activity with the children in the classroom. After the first two weeks the teachers did not require any additional assistance in implementing the lessons as the teachers were able to effectively implement the physical activity lessons.

Direct observation of physical activity lessons using SOFIT. During the first three months physical activity levels of the children were assessed five times per week (daily) in the classrooms after teacher training in the physical activity program and baseline SOFIT data were collected. Three students from each classroom were randomly selected to be observed in both control and intervention sites to provide a measure of how active students were during classroom lessons. In 20-second intervals, for up to 20 minutes, the students' physical activity intensity levels were estimated and recorded using the SOFIT rating scheme (i.e., one = lying down to five = jogging or running). During observations, research assistants also indicated how often teachers participated in active lessons with their students by rating them on a three-point scale (i.e., none, somewhat, very active participation). This particular measure provided an indication of effective role modeling for active lessons.

RESULTS

Body Mass Index

The six-month change in BMI for the intervention group was $-2.0 \pm 1.1\%$ and control $0.5 \pm 0.9\%$, respectively (NS). However, change in BMI from baseline to six months was

significantly influenced by exposure to the activity lessons. As minutes of exposure to moderate to vigorous physical activity increased, the change in body mass index decreased, ($R^2 = 0.39, p < 0.05$).

Early Literacy Skills

There was no significant difference between preschools for picture naming. Rhyming significantly ($p < 0.01$) improved in the PA group from baseline (0.7 ± 0.3) to 6 months (3.0 ± 0.5) compared to the controls (0.7 ± 0.2 to 1.9 ± 0.4 , $p < 0.05$), resulting in between group differences at 6 months, $p < 0.01$ (see figure 1). Higher scores for alliteration and rhyming indicate greater early literacy skills and phonological awareness. Alliteration significantly ($p < 0.01$) improved in the PA group from baseline (0.5 ± 0.2) to 6 months (2.0 ± 0.4) compared to controls (0.5 ± 0.2 to 0.9 ± 0.3 , $p < 0.05$), resulting in between group differences at 6 months, $p < 0.01$, (see figure 2).

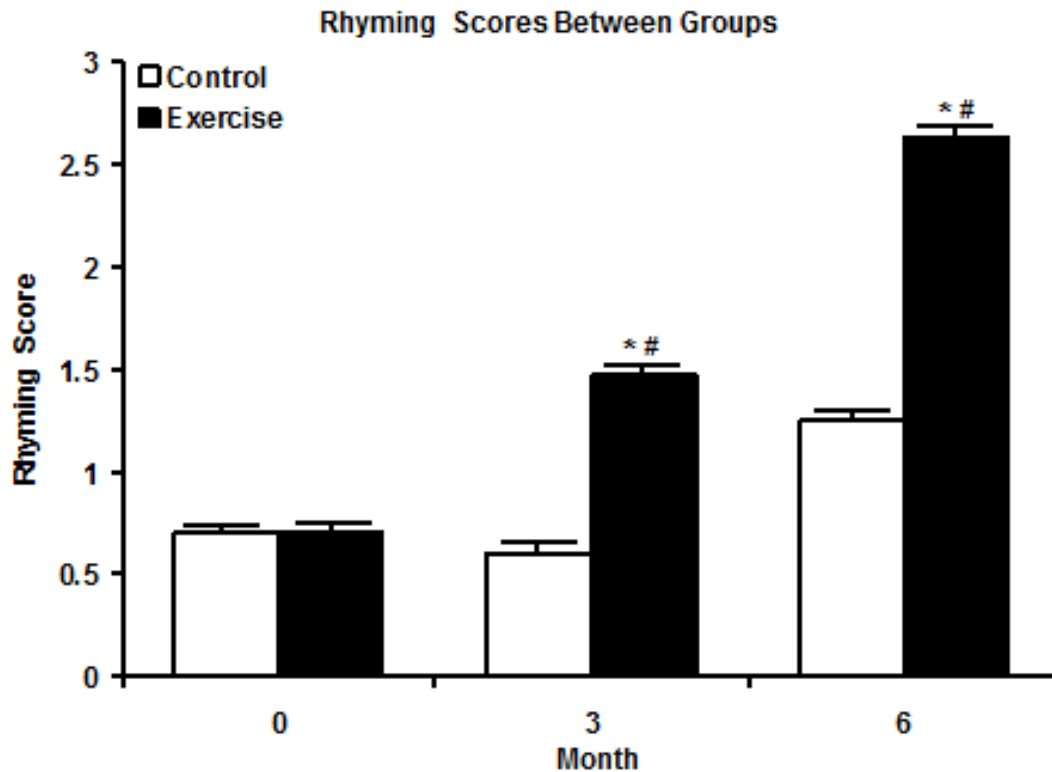


Figure 1. Mean Rhyming scores between groups. Values are means \pm SE; * $p < 0.05$ from 0 week within group, # between groups.

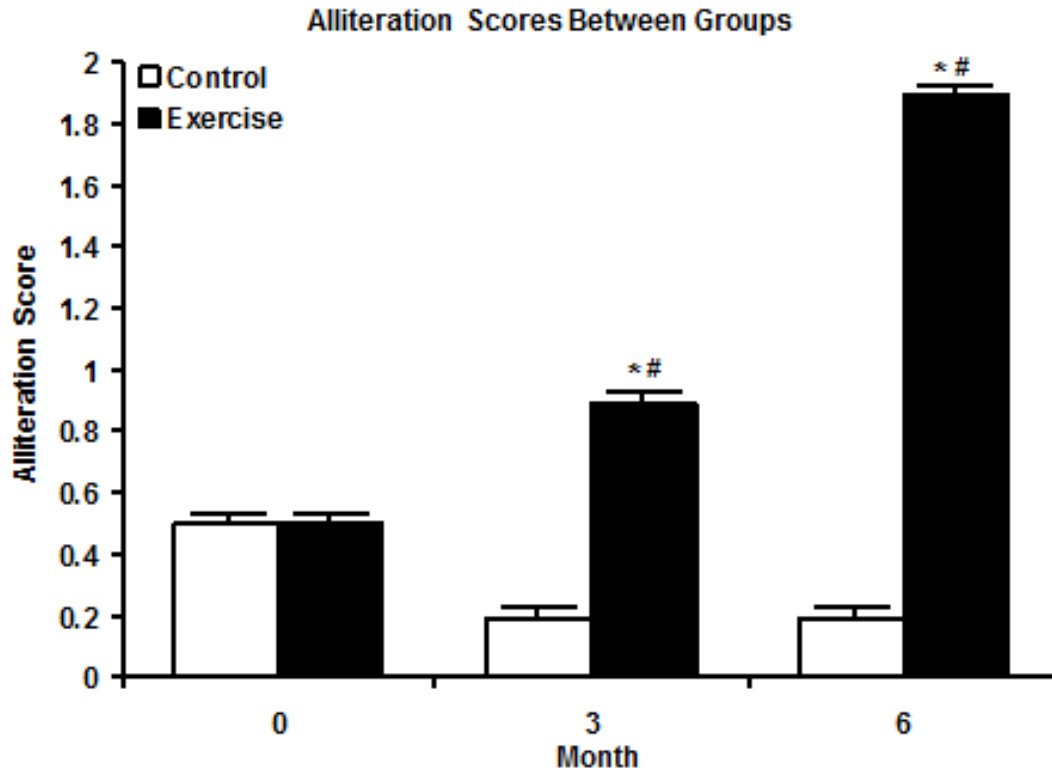


Figure 2. Mean Alliteration scores between groups. Values are means \pm SE; * $P < 0.05$ from 0 week within group, # between groups.

SOFIT

During the first three months observers conducted SOFIT observations in all of the intervention and control classrooms five times per week to determine student activity intensity levels. In months four through six staff conducted SOFIT observations one day per month in both the intervention and control sites and all teachers in each preschool.

Students at the intervention site performed significantly greater levels of physical activity in the classroom than students at the control site at three (intervention, 3.6 ± 0.2 vs. control, 2.6 ± 0.2 , $p < 0.05$) and six (intervention, 3.5 ± 0.1 vs. control, 2.6 ± 0.2 , $p < 0.05$ months; higher scores indicate higher activity intensity levels. Preschoolers at the control site were primarily sitting during academic lessons, whereas students in intervention site were primarily moving during the activity lessons.

The results indicated that adherence to the program was greater than 95%, meaning that students were obtaining half (30 minutes) of the daily 60 minutes/day of recommended structured physical activity (Active Start, 2008) while being observed by the research staff. In addition, teachers reported that they were performing the physical activity program at least eight times (twice per day, four days per week) per week or more in the absence of the investigators (maintenance phase).

During SOFIT observations, staff also indicated the level of participation by teachers during an active lesson. Overall teacher participation was related to SOFIT scores for students in the intervention schools but not the control schools. At baseline teachers were not active at all (SOFIT score of zero) but increased to very active (SOFIT score = 3.8) at three months, which was maintained at six months (SOFIT score = 3.5). The analysis for the teacher modeling was performed using only the intervention schools because teacher participation had no effect on the activity level of students in the control schools.

Teacher Satisfaction Survey

At the end of the study we gathered information from the teachers (n=8) regarding the perception of the program and the likelihood that the program could be adopted into a preschool classroom (see Table 3 for results). In general, teachers reported that the program was easy to implement, children enjoyed the program, had a positive influence on the children learning and helped them focus better. Most encouraging, the teachers indicated that they would have their class participate in the physical activity program again.

TABLE 3
Ratings for selected characteristics of physical activity program reported by teachers

Characteristic	Percent Reported				
	Strongly Disagree	Disagree	Neutral	Agree	Strong Agree
Did you receive enough support/training?	0	0	0	20	80
The PA* program was easy to teach to children.	0	0	0	0	100
The PA program was easy to incorporate in the daily curriculum.	0	0	0	40	60
The children enjoyed the PA program.	0	0	0	0	100
The amount of time required for the PA program was appropriate for the classroom.	0	0	0	20	80
The PA program made a positive influence on student behavior.	0	0	0	40	60
The PA program helped my students release excess energy so they could concentrate.	0	0	0	0	100
The PA program had a positive impact on students' learning.	0	0	0	80	20
Having PA as part of the daily schedule helped students focus on learning activities.	0	0	0	80	20
If given the opportunity, I would have my class participate in the PA program again.	0	0	0	0	100

Note. PA = physical activity. N = 10.

DISCUSSION

To our knowledge this is the first study to indicate that a teacher-directed physical activity program in a Head Start center serving African American preschoolers is effective at increasing physical activity and improving measures of early literacy. It appears that physical activity can be maintained for at least three months (maintenance phase) without direct supervision with the potential for decreasing BMI and improving early literacy development. The teachers indicated that they felt the program was easy to administer, enjoyable, and made an impact on children's learning in the classroom.

Despite no significant difference between groups for the change in BMI at six months, it does appear that even over a short period (six months total) that a physical activity program may be effective decreasing BMI compared to sedentary behavior.

Therefore, over a longer period of time (several years) a sustained physical activity program, such as the one used in this study may be an effective strategy for reducing BMI in preschool children.

Early literacy skills were significantly improved in the physical activity group. In the current study, we found that alliteration and rhyming, both associated with greater early literacy skills and phonological awareness (Tomprowski, Davis, Miller, & Naglieri, 2008) were significantly improved in the physical activity group at three months and maintained at six months compared to the control classrooms. The findings of improved academic achievement are important as literacy skill development in early childhood contributes to children's long-term academic success (Walker, Greenwood, Hart, & Carta, 1994). Many young children face significant challenges in learning to read because they lack these essential early literacy skills (phonological awareness, letter knowledge, print awareness) when they begin school. Weaknesses in early literacy skills and subsequent reading failure are most common among low-income, non-white children such as those in the current study (Snow, Burns, & Griffin, 1998). Results from this study suggested that a physical activity program that was incorporated within the preschool classroom improved early literacy and was maintained even after there was no contact between the investigators and teachers. The physical activity lessons may provide an important strategy to improve early literacy in minority preschoolers, a group at high risk for delays in early literacy development. Although not measured in the current study, some possible mechanisms for the association between physical activity and academic performance include concentration, memory, cognitive processing, and classroom behavior (Davis et al., 2007). Potential mechanisms for the association of physical activity and improvements in academic performance need further exploration in studies designed and powered for this purpose.

According to the SOFIT observation the physical activity levels in the classroom were increased in the intervention classrooms compared to the control classrooms which is important because increased levels of physical activity are known to increase fitness (Gutin et al., 2002; Gutin, Yin, Humphries, & Barbeau, 2005; Owens et al., 1999). We reported that the intervention classrooms completed the physical activity lessons 95% of the time and the preschoolers were obtaining half (30 minutes) of the daily 60 minutes/day of recommended structure physical activity (Active Start, 2008) through physical activity incorporated into curriculum lessons. Although we were unable to measure the physical activity outside of the classroom (i.e. recess, playground) it is unlikely there were differences between the intervention and control sites since both schools followed identical schedules throughout each day. Instead, the impact of the physical activity program on early literacy was most likely attributed to the additional physical exercise that was scheduled in the classroom versus the physical activity that occurred as a result of outside play or recreational time at the control site.

According to the teacher survey the teachers reported that they were still using the physical activity program at least four days per week, two times per day in the absence of staff support during the final three months of the study. Although teachers indicated continued use of the physical activity program, these results are limited by self-report and should be objectively verified in any future studies. Nevertheless, these findings are important because teachers and parents have assumed that preschool children are very active and engage in sufficient physical activity (Benham-Deal, 1993a; Sallis et al.,

1988). However, a systematic review by Tucker (2008) examined a total of 39 studies (published from 1986 – 2007) from seven countries (United States, Scotland, Finland, Australia, Chile, Estonia, Belgium) to establish an accurate reflection of the physical activity levels of preschool children. With only 54% of preschool children in this review found to be sufficiently physically active, and rising obesity rates within this age group, the idea of incorporating physical activity within the classroom may be an effective strategy for increasing physical activity in a preschool setting.

It was important to assess the sustainability of the program as few research studies have the resources to ensure that their interventions can be sustained (Bull, Gillette, Glasgow, & Estabrooks, 2003; Oldenburg, Sallis, French, & Owen, 1999). We designed the current study to be a low burden, minimal cost intervention that would not decrease academic instruction time, would not increase teacher preparation time, and would be enjoyable for students and teachers. According to the results from teacher survey, the program was well received by teachers. Importantly, the acceptance and enthusiasm for the physical activity program was corroborated by findings from a post-intervention survey administered to teachers in an effort to determine if the physical activity program was continued in the absence of the investigators. Teachers were surveyed three months after completion of the physical activity program and without any contact from our staff over the three month period. All of the teachers indicated that they were using the physical activity program at least eight times (twice per day, four days per week) per week or more.

Several limitations of the study include the short duration of the study, the use of only two preschools, the lack of significant changes in body mass index, and the use of self report to assess the usage of the physical activity program in the final three months of the study absent investigator support. However, despite these limitations the fact that we found significant differences in just a short period of time (six months) suggests that it may not take much time for improvements in early literacy to occur in response to physical activity. The use of only two preschools limits the scope of the study and may have attributed to the non-significant changes in body mass index even though we did see a small decrease in the intervention site compared to the control site. These findings should be studied in a future and larger randomized study. Despite these limitations it appears that the incorporating physical activity into the Head Start curriculum can improve early literacy development in preschoolers.

A strength of the study was that both quantitative and qualitative methods were used to allow for a more thorough examination of program fidelity and implementation issues. Quantitative data regarding minutes of physical activity and number of lessons taught were collected weekly, which helped to determine if teachers were implementing the intervention with fidelity (both time and content of the lesson as measured by SOFIT).

FUTURE RESEARCH

The present study suggests that a three-month physical activity intervention can improve early literacy in African American children enrolled in Head Start. Future studies should focus on longer term studies of at least a year looking at different amounts of physical

activity on improving academic achievement. Understanding the effect of physical activity on academic achievement in preschoolers may provide insight into exercise guidelines for academic achievement. Additionally, a longitudinal study evaluating the effects of performing increased physical activity while in preschool on academic achievement in K-12 may elucidate the long-term effects of physical activity on academic achievement.

CONCLUSION

In summary, a low cost, teacher-directed, physical activity program may promote daily physical activity, increases early literacy, and may attenuate increases in body mass index in preschool children, a group at an increased risk for poor literacy development. One of the major advantages of the physical activity program is it is a minimal intervention that can be easily disseminated, requiring minimal change to the current curriculum, few additional supplies (if any), and minimal cost to schools. Additionally, the fact that the physical activity program was sustained by teachers without any further contact by the investigators, speaks to the overall favorable perception and acceptance for the physical activity program approach by teachers, students, and school administrators. Continued research is needed to develop and evaluate strategies to provide greater exposure to in class physical activity programs since physical activity time was associated with decreases in body mass index.

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