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Original Research

Active Science® pilot study: Promoting physical activity and science learning among children

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ABSTRACT

Background: Afterschool programs (ASPs) have been identified as ideal settings where children can accumulate a significant portion of their total daily physical activity (PA). The purpose of the current study was to assess the effectiveness of the Active Science program in promoting PA and science learning in different site locations across the U.S. **Methods:** Participants were 72 children (35 females, mean age = 9.2 years, standard deviation [SD] = 0.9) from five YMCA afterschool childcare sites located in five states. The 6-week Active Science program was implemented twice/week for 60 min at a site. The participants completed 30 min of PA followed by a science lesson delivered through the Active Science Mobile App. Sites were randomly assigned to Active Science and the control (i.e., regular ASP). After 6 weeks, the sites switched to enable both groups to receive the intervention. Science tests and accelerometers were used to measure science performance, steps, and moderate-to-vigorous PA (MVPA) minutes. The pre- and post-results were compared and analyzed by ANOVA. **Results:** For PA, participants had significantly higher steps/30 min when they completed the Active Science program compared to the traditional ASP, mean = 1826, SD = 571, mean = 685, SD = 161, respectively, $F(1,55) = 280$, $P < 0.001$. Significant differences were found with MVPA%, mean = 38.16%, SD = 20.05%, mean = 30.03%, SD = 14.83%, respectively, $F(1,55) = 44.8$, $P < 0.001$. For science learning, the pre- and post-improvement was significant for the Active Science group, $P < 0.001$. Average science test score for pre- and post-tests were mean = 57.14, SD = 20.56, and mean = 75.24, SD = 15.61, respectively. For the control group, the pre- and post-improvement was not significant, $P > 0.05$. **Conclusion:** The results supported that children had significantly higher PA levels and improved students' science scores when they participated in Active Science.

KEY WORDS: Adolescent, community-based research, exercise, health promotion

INTRODUCTION

One of the major factors contributing to childhood obesity is physical inactivity. Physical inactivity is associated with numerous health risks, including heart disease, cancer, diabetes, hypertension, as well as anxiety and depression [1]. It is recommended that children and adolescents participate in 60 min of moderate-to-vigorous physical activity (MVPA) daily [2]. Results from national surveillance studies suggest that the majority of children (58%) do not meet this guideline [3]. Given this situation, both public and private sectors have been called upon to improve the levels of PA among children and adolescents. Despite these recommendations, many children are not sufficiently active either at school or afterschool.

Around 8.4 million children spend an average of 8 h/week in afterschool programs (ASP) [4]. Recently, ASPs have been identified as ideal settings where children (5-14 years) can accumulate a significant portion of their total daily, recommended level of MVPA. Recent studies have found that interventions to modify PA practices at ASPs can increase children's PA [5-11]. Unfortunately, many ASPs have not been able to provide adequate PA opportunities for children. A systematic review of state-level ASPs was conducted to identify existing standards and policies and the report concluded that policies promoting PA within these organizations were largely absent. Currently, only 14 states and one national organization (i.e., National Afterschool Association) have developed guidelines for the amount of PA children should accumulate while in ASPs [12,13].

Physical inactivity is a serious concern among all children. In addition, many schools, especially ones in poorer communities, have reported unsatisfactory academic test scores in subjects such as science, technology, engineering, and math (STEM). States with the highest prevalence of child obesity also have the worst elementary school STEM scores in a national ranking [14]. In addition, several large-scale studies have shown a significant negative correlation between body mass index and academic performance in children [15-17]. PA has been associated with increases in school performance including concentration, memory, and classroom behavior [18,19]. Recent publications have conclusively demonstrated that PA is essential for promoting academic achievement [20,21]. The Centers for Disease Control and Prevention has recommended the integration of PA into academic lessons as a strategy to promote regular PA and support academic success [9]. Therefore, afterschool organizations should aim to integrate PA and academic components into their programs to promote movement and learning. Due to the limited ASPs that integrate activity and educational experiences, the Active Science program was created to promote PA as well as to support science education among afterschool children.

The Active Science® Approach

The Active Science program was founded in 2009 through support from the U.S. Department of Health and Human Services, with additional support from various charitable foundations and private sources. Active Science is a federally registered trademarked and nonprofit service that is available for community organizations and ASPs to help support PA and academic achievement in school-age children. Active Science integrates PA and educational experiences. This approach of using PA as a component of academics is not unique to Active Science, and others have successfully demonstrated beneficial effects on activity and academics. At this time, the Active Science program is delivered to schools through the YMCA network that in turn collaborates with schools and teachers. There is no fee for individual teachers to be involved in the program. The present study was specific to the approach used by Active Science as described herein. The website where more information can be found is www.activescienceforkids.org.

The main objective is to improve PA while supporting educational achievement in afterschool and childcare settings and directly during school time. Active Science encompasses PA within exploratory-type educational experiences to create "active education" or "exerlearning" environments. The Active Science approach incorporates the use of interactive technologies. Considering children's affinity toward online experiences, digital products, and social media, these technologies add an exciting aspect to this program.

In the afterschool Active Science program setting, children generate, collect, and analyze their own PA data using digital monitors (i.e., pedometers) that allow users to upload personal metrics (i.e., steps, distance, and calories) to an interactive website for evaluating and tracking progress. In essence, children play, explore, and discover while staying active. In an initial in-school pilot study, the results showed that the Active Science program improved PA levels by 50% and increased science skills and knowledge by 30% among middle school students [21]. In a follow-up study in the afterschool setting, the results also demonstrated that children who participated in Active Science improved their PA levels and science performance [22]. However, both studies did not randomize participants, which limited the strength of the evidence.

The purpose of the current study was to assess the effectiveness of the Active Science program in multiple settings and states. The hypotheses are: (1) Children are more physically active in the Active Science program than when they are in a regular ASP, (2) children in the Active Science program have greater improvement in science test scores compared to children in the control group.

METHODS

Participants and Setting

A total of 72 children (35 females, mean age = 9.2 years, standard deviation [SD] = 0.9) from five YMCA afterschool childcare sites located in five states (i.e., New Jersey, New York, Rhode Island, Texas, Pennsylvania) participated in the study. Each site was staffed with an afterschool counselor (i.e., a YMCA employee) who was responsible for supervising and implementing the Active Science program. Counselors received 3 h of training as part of their involvement in the study. The staff to student ratio across the sites ranged from 1:10 to 2:25 depending on the number of children attending on any given day. The pilot study was carried out in a variety of environments. Two sites ran the program in fitness facilities, two in elementary schools, and one site ran the program in a camp setting. All sites had a similar schedule of offerings that consisted of homework/academic time with counselor support/tutoring, snack and beverage, and structured (e.g. staff led sports and/or games) and unstructured (i.e., free-play) activities.

In each of the YMCAs, the participants were recruited from children in the 3rd through 5th grades (ages 9-11 years) due to the level of academic content in the curriculum. The YMCA staff identified all participants in this age range and asked them to participate in the study. Written parental/guardian consent and child assent forms were completed before study participation. Approval for the study was obtained from the college's Institutional Review Board.

Design

A crossover research design was utilized for this study. Sites were randomly assigned to one of two groups: Active Science intervention and the control. For the first 6 weeks of the program, three sites (n = 39, female = 22, age mean = 9.1, SD = 1.1) were randomly assigned to the Active Science group and the other two (n = 33, female = 20, age mean = 9.3, SD = 0.8) were in the control groups. At the completion of the 6 weeks, the sites switched to enable both groups to receive the intervention. A crossover design allowed the sites to act as their own controls, enabling comparisons between and within groups.

Measures

Physical Activity

PA levels and intensity were recorded using the ActiGraph wGT3X monitor from Actigraphcorp (ActiGraph, LLC., Pensacola, FL). Participants were instructed to wear the accelerometer on their waists during the Active Science session. Specifically, steps per hour and MVPA percentages were measured to assess PA in this study. Internal Device MVPA cut points were utilized with cut point ranges for exercise intensity in Actigraph Software based on the values determine through efficacy trial in Freedson Children, 2005 [23]. PA results were automatically sent from the device to an internet cloud based Actigraphcorp Admin portal only accessible to researchers and not by participants or YMCA staff.

Science learning

A 21-question test (scores ranged from 0 to 21) for the content of the test was developed to measure science inquiry and knowledge. The test was implemented at the beginning and the end of the 6-week program for all participants. The content of the test assessed the skills that were taught in the Active Science curriculum with a focus on the ability to read and interpret data from figures and tables and to understand and implement the scientific method (e.g., make a hypothesis, record and collect data, draw conclusions). The test demonstrated good reliability with an internal consistency between 0.70 and 0.81. The content of the pre- and post-tests was similar but not identical. Two middle school science teachers reviewed the science test and provided feedback to assure that the content was age and grade appropriate.

Procedures

Intervention

The 6-week Active Science program was implemented twice per week for 60 min at a YMCA afterschool site. The afterschool counselors led the program with little to no experience in physical education or STEM.

During each 60-min Active Science session, the children participated in the program that entailed two components: PA (~30-40 min) and science learning (~15-20 min). The participants completed 30-40 min of PA followed by a science lesson delivered through the Active Science Mobile App. The YMCA staff led the participants through the PA curriculum in the gymnasium, playground, or sports field. The physical activities incorporated into the curriculum included a variety of team-based games, traditional sports and fitness stations, and time periods of unstructured free play. The goal of the PA curriculum was to engage participants with different levels of fitness and skills in fun, moderately intense, activities.

In addition to the accelerometer, participants also wore a Digiwalker SW-701 (Yamax Corporation, Tokyo, Japan) pedometer to track their PA data during each session. After the PA session was completed, the participants retrieved the data from the pedometer and recorded their steps, distance, and calories onto the Active Science mobile application. The mobile app was administered through Kurio 7 computer tablets that participants used for the intervention portion of the study. Once the data were recorded, students continued through the Active Science Mobile app where they would complete one STEM-driven academic lesson per day. In each lesson, participants would view a series of figures and tables generated from the data that displayed the class and individual information (i.e., steps, distance, and calories). The participants then completed an analysis of the data by answering a variety of questions that focused on general scientific inquiry skills, such as graphical interpretation and the ability to draw conclusions from data. The children participated in the science inquiry portion of each lesson for about 15 min, twice per week, for 6 weeks (12 lessons).

Control

Students in the control group participated in the regular ASP offered by their local YMCA. Four participants from each site (n = 20) were randomly selected to wear an Actigrachcorp wGT3X Accelerometer in addition to the pedometer each day during their entire ASP. YMCA staff members were trained to record the total amount of time each student wore the devices along with their PA data (steps, distance, and calories) at the conclusion of each afterschool session.

Statistical Analysis

To detect the intervention effect on science learning, the pre- and post-science tests for the first 6-week intervention were analyzed. A 2 time (pre vs. post) by 2 group (Active Science vs. control) ANOVA analysis was implemented. To assess the differences of PA between Active Science and the traditional ASP, repeated measure analysis was implemented. All participants' PA data during the Active Science period (i.e., 6 weeks) was compared to their own PA data during the control period (i.e., 6 weeks). All analyses were run by SPSS 21.0.

RESULTS

Table 1 displays the PA and science outcomes of the study. For PA, the repeated measure analysis revealed that participants had significantly higher steps/30 min when they ran the Active Science program compared to their participation in the traditional ASP, mean = 1826, SD = 571, mean = 685, SD = 161, respectively, F (1,55) = 280, $P < 0.001$. Significant differences were found with MVPA%, mean = 38.16%, SD = 20.05%, mean = 30.03%, SD = 14.83%, respectively, F (1,55) = 44.8, $P < 0.001$.

For science learning, the time effect and the interaction effect between time and group were significant, F (1,36) = 21.88, $P < 0.001$, $\eta^2 = 0.38$; F (1,36) = 4.16, $P < 0.05$, $\eta^2 = 0.10$, respectively. Simple effect test showed that for the Active Science

Table 1: Average steps, MVPA%, and science scores of participants

Category	Steps/30 min	MVPA%	Science score
Active Science (n=72)	1826 (571)***	38.16 (20.05)***	75.24 (15.61)***
Control (n=72)	685 (161)	30.03 (14.83)	57.14 (20.56)

***$P<0.001$. MVPA: Moderate-to-vigorous physical activity group, the pre- and post-improvement was significant, $P < 0.001$. Average science test score for pre- and post-tests was mean = 57.14, SD = 20.56, and mean = 75.24, SD = 15.61, respectively. For the control group, the pre- and post-improvement was not significant, $P > 0.05$. Average science test scores for pre- and post-tests were mean = 58.46, SD = 21.79 and mean = 69.39, SD = 14.07, respectively.

DISCUSSION

The purpose of the current study was to assess the effectiveness of the Active Science program delivered in different site locations across the U.S. The results supported that children had significantly higher PA levels when they participated in Active Science compared to their traditional ASP. In addition, children who participated in Active Science significantly improved their science performance compared to the children in the control group.

Previous research has demonstrated that children who participated in Active Science in the afterschool setting improved their PA levels and science performance [21]. However, the previous study failed to demonstrate the differences between the interventional and control groups. This may have been due to the limited number of participants and individual differences between groups. Using a cross-over study design, the current study addressed the concerns of group differences and ethical issues by having all subjects participate in the intervention (i.e., crossover design). The results supported the hypotheses that Active Science improves children's PA levels and science performance in an afterschool setting. Unlike previous studies where data were collected only at one location, the current study examined the program at five different YMCAs across the country. The diverse demographics of the participants further supported the evidence of the external validity of the program.

Children who participated in Active Science improved their PA levels significantly during the program. As participants entered their steps taken, distance traveled, and calories burned from their accelerometer into the mobile app at the end of the PA sessions, they were motivated to accumulate more PA and compete against each other. Previous evidence has demonstrated that wearing activity monitors improve participants' PA levels [24,25]. For the children who participated in Active Science, wearing an accelerometer, checking, and entering their activity data, all served as reinforcement for their PA behaviors. The results suggest that ASPs could adopt similar strategies, such as providing activity monitors (i.e., pedometers, accelerometers) to motivate children to be more active.

The innovative approach of Active Science integrates PA with science learning. Using the interactive mobile app, each child controlled their own pace to navigate through the simple science lessons. Since all of the science lessons used data from the participant's own PA, children may feel the science concepts were more relevant because it was about their own PA data. Research has shown that children show more interest in science learning when they collect and analyze their own data [26]. Due to the personal attachment to the data, Active Science provided a positive learning experience for children, which may have developed their interest in science learning.

Since the Active Science program did not prescribe the types of physical activities that were implemented by the YMCA staff, one limitation of the study, from a research perspective, was there no was control over what activities were chosen and how they were implemented. During the staff training, it was emphasized that the physical activities needed to be moderate-to-vigorous intensity, but there was no one on site to oversee this was happening. However, from a practical perspective, it is an advantage as the staff has the flexibility to implement the PA that fits their curriculum and setting (e.g., space of the gym, weather, etc.). In addition, although this study was a cluster cross-over design, the sample size was too low to calculate the impact of clustering. This should be addressed in future studies.

CONCLUSION

This study showed that implementing the Active Science approach improved PA levels and increased science learning in the afterschool setting. The results of the study supported previous preliminary evidence that science learning in school-age children could be achieved through PA involving fun and enjoyable activities. Future studies should implement qualitative evaluation on the program from children who participated in the study as well as staff who delivered the program.

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REFERENCES

1. Institute of Medicine of the National Academies. Educating the Student Body: Taking Physical Activity and Physical Education to School. Washington, DC: Institute of Medicine of the National Academies; 2013.
2. Centers for Disease Control and Prevention. The Association between School-Based Physical Activity, Including Physical Education, and Academic Performance. Atlanta GA: U.S. Department of Health and Human Services; 2010.
3. Beets MW, Rooney L, Tilley F, Beighle A, Webster C. Evaluation of policies to promote physical activity in afterschool programs: Are we meeting current benchmarks? Prev Med 2010;51:299-301.
4. After School Alliance. America after 3PM National Report: The Most In-Depth Study of How America's Children Spend their Afternoon; 2009. Available from: http://www.afterschoolalliance.org/AA3_Full_Report.pdf.
5. Beets MW, Beighle A, Erwin HE, Huberty JL. After-school program impact on physical activity and fitness: A meta-analysis. Am J Prev Med 2009;36:527-37.
6. Beets MW, Wallner M, Beighle A. Defining standards and policies for promoting physical activity in afterschool programs. J Sch Health 2010;80:411-7.
7. Beighle A, Beets M, Erwin H, Huberty J, Moore J, Stellino M. Promoting physical activity in afterschool programs. After Sch Matters 2010;11:24-32.
8. Beets MW, Shah R, Weaver RG, Huberty J, Beighle A, Moore JB. Physical activity in after-school programs: Comparison with physical

activity policies. J Phys Act Health 2015;12:1-7.
9. Dzewaltowski DA, Rosenkranz RR, Geller KS, Coleman KJ, Welk GJ, Hastmann TJ, *et al*. HOP'N after-school project: An obesity prevention randomized controlled trial. Int J Behav Nutr Phys Act 2010;7:90.
10. Gortmaker SL, Lee RM, Mozaffarian RS, Sobol AM, Nelson TF, Roth BA, *et al*. Effect of an after-school intervention on increases in children's physical activity. Med Sci Sports Exerc 2012;44:450-7.
11. Wiecha JL, Hall G, Gannett E, Roth B. Development of healthy eating and physical activity quality standards for out-of-school time programs. Child Obes 2012;8:572-6.
12. Matthews CE. Physical activity in the United States measured by accelerometer: Comment. Med Sci Sports Exerc 2008;40:1188.
13. Pate RR, O'Neill JR. After-school interventions to increase physical activity among youth. Br J Sports Med 2009;43:14-8.
14. U.S. Department of Education. National Center for Education Statistics; 2014. Available from: http://www.ed.gov/index.jhtml. [Last accessed on 2014 Jun 01].
15. Castelli DM, Hillman CH, Buck SM, Erwin HE. Physical fitness and academic achievement in third - And fifth-grade students. J Sport Exerc Psychol 2007;29:239-52.
16. Cottrell LA, Northrup K, Wittberg R. The extended relationship between child cardiovascular risks and academic performance measures. Obesity (Silver Spring) 2007;15:3170-7.
17. Robert Wood Johnson Foundation. Overcoming Obstacles to Health in 2013 and Beyond. Available from: http://www.activinglivingresearch.org. [Last accessed on 2014 Jul 10].
18. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. Med Sci Sports Exerc 2006;38:2086-94.
19. Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, *et al*. Evidence based physical activity for school-age youth. J Pediatr 2005;146:732-7.
20. Datar A, Sturm R, Magnabosco JL. Childhood overweight and academic performance: National study of kindergartners and first-graders. Obes Res 2004;12:58-68.
21. Finn KE, Yan Z, McInnis KJ. Active Science®: Integrating physical activity and science learning into the afterschool environment. Am J Health Educ 2015;46:323-8.
22. Finn K, McInnis K. Teacher and student perceptions of the Active Science curriculum: Incorporating physical activity into middle school science classrooms. Phys Educ 2014;71:234-53.
23. Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. Med Sci Sports Exerc 2005;37 11 Suppl: S523-30.
24. Bravata DM, Smith-Spangler C, Sundaram V, Gienger AL, Lin N, Lewis R, *et al*. Using pedometers to increase physical activity and improve health: A systematic review. JAMA 2007;298:2296-304.
25. Catrine TL. Taking steps toward increased physical activity: Using pedometers to measure and motivate. Research Digest. Vol. 3. Washington, DC: President's Council on Physical Fitness and Sports; 2002. p. 1-8.
26. Weiss IR, Banilower ER, McMahon KC, Smith PS. Report of the 2000 National Survey of Science and Mathematics Education. Chapel Hill, NC: Horizon Research, Inc.; 2001.

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