Structured Physical Activity and Math Progress of Students with Autism Spectrum Disorder

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Abstract

The literature is clear that school performance of K-12 students with disabilities is positively influenced by physical education and physical activity. Additional findings indicate that physical activity helps K-12 students with intellectual disabilities improve academic work completed in the classroom, although research on students with autism spectrum disorder (ASD) are limited. While a plethora of research has been conducted to investigate sensory integration in students with ASD, this study is expanded to investigate the daily trend patterns of elementary students who have ASD with structured sensory-based and aerobic physical activity interventions. Six elementary students with ASD participated in this modified single-case design investigation. The study included a four-day baseline phase, followed by 13 days of interventions, which included structured physical activity based on the students’ needs, followed by a four-day reversal phase, and then four more days of interventions. During each day of the study, participating students with ASD completed a one-minute individualized math progress paper, immediately following physical activity. Results indicated a decrease in math progress in five out of six students with ASD, when interventions were withdrawn, and an increase was indicated after interventions were implemented. By the end of the study, all six students with ASD demonstrated improved progress in mathematics with the implementation of the interventions.
Structured Physical Activity and Math Progress of Students with Autism Spectrum Disorder

Recent evidence indicates regular physical activity positively influences academic performance of school children (Castelli, Hillman, Buck, & Eri, 2007; Centers for Disease Control Prevention, 2010; Chomitz, Slining, McGowan, Mitchell, Dawson, & Hacker, 2009; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Grissom, 2005; Welk, Jackson, Morrow, Haskell, Meredith, & Cooper, 2010; Wittberg, Northrup, Cottrell., & Davis, 2010). Other than a few findings on students with intellectual disabilities, little has been published on the impact of physical activity on the academic performance of students with disabilities, although existing research indicates movement and physical activity impact brain and cognitive function (Jensen, 2001; Van Praeg, Kempermann, & Gage, 1999). Students with developmental disabilities have been found to improve their mathematical, language arts, and reading skills through regular engagement in physical activity and school physical education programs (Tremarche, Robinson, & Graham, 2007). Extending this work to investigate the influence of physical activity and school physical education programs on academic skills of students with Autism Spectrum Disorder (ASD) appears to be a logical progression for this research.

Literature Review

Physical Activity, Academic Performance, and Developmental Disabilities

Physical activity, kinesthetic programs, and motor skill movements strengthen cognitive functioning in young people with intellectual disabilities (Berthos, 2000; Corso, 1994; Hallet, 1994; Jensen, 2001). Academic performance for students with intellectual disabilities has been associated with participation in school physical education programs and physical activity (Etnier, Han, Landers, Nowell, Petruzello, & Salazar, 1997). However, it is difficult to show a causal link between physical education and physical activity with academic performance of this special student population, although several studies have demonstrated a relationship exists with students without disabilities (Caterino & Pelak, 1999; Dwyer, et al., 1996; Shephard, 1996, 1997). Researchers suggest the impact of exercise engagement on producing neurons (Jensen, 2001) and the development of brain cells (Van Praeg, Kempermann, & Gage, 1999) might play a role in this relationship. However, limited research has been conducted on the impact of physical activity on the academic performance of students with disabilities.

In a recent study by Everhart Dimon, Stone, Desmond, & Casilio (2012), intermediate elementary students with intellectual disabilities improved in daily math and language arts performance following 10-minute structured aerobic activity prior to academic work. Although there was no indication of consistent improvement in the baseline trend data for a majority of the primary students in their academic work, results indicate improvement trends for some students (Everhart, et al., 2012). In the Everhart, et al. (2012) study, teachers of elementary students with intellectual disabilities commented that students’ focus during academic work was much stronger following the structured aerobic activity. Similar studies need to be conducted with students who have other types of disabilities, such as those with autism spectrum disorder.

Sensory Integration and Children with Autism Spectrum Disorder (ASD)
Approximately one in 88 children each year is diagnosed with autism spectrum disorder (ASD). ASD includes a wide range of developmental disabilities affecting communication, language processing, and peer socialization. It is challenging to find effective strategies to help children, who have this neurodevelopment disorder, with their under (hypoactive) or over (hyperactive) reaction to certain sensory stimulations. When sensory dysfunction occurs, information is not reaching the central nervous system or being processed properly (Cheatum & Hammond, 2000). Accommodating for sensory overload is challenging enough, but teachers must also determine instructional adaptations and strategies to help increase the focus of children with ASD (Alexander & Schwager, 2012) and, subsequently, help them achieve improvement in academics.

In order to accommodate for sensory dysfunction, professionals in the field have frequently used sensory integration activities, particularly in conjunction with adapted physical education (Sowa & Muelenbroek, 2012). Of the seven sensory systems, three systems are the primary focus of these sensory integration strategies. These three systems involve (a) proprioceptive (involving muscles and joints), (b) vestibular (involving gravity and movement), and (c) tactile (involving touch) (Corwin, 2005). School physical education teachers and adapted physical educators continue to work closely with occupational therapists and special education teachers as part of this type of sensory-related, individualized prescribed physical activity intervention for students with ASD.

Although research is not conclusive about the impact of sensory integration on children with ASD (Dawson & Watling, 2000; Smith, et al., 2005; Sowa & Muelenbroek, 2013), it is still important to provide structured physical activity for students with ASD, due to the positive outcomes associated with physical activity and ASD (Castelli, Hillman, Buck, & Eri, 2007). Since research indicates students with disabilities improve academic performance by regular engagement in physical activity, this intervention also might help students with ASD improve educational outcomes (Centers for Disease Control Prevention, 2010; Chomitz, Slining, McGowan, Mitchell, Dawson, & Hacker, 2009; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Grissom, 2005; Welk, Jackson, Morrow, Haskell, Meredith, & Cooper, 2010; Wittberg, Northru, Cottrell., & Davis, 2010). The purpose of this study was to determine the impact of regularly structured, individualized physical activity for students with ASD prior to daily math work on the mathematical trend data of children with ASD.

**Methods**

Six elementary students with ASD participated in a modified, single-case design study with a baseline phase for four days, a 13-day intervention phase, a four-day reversal phase, and four more days of the intervention. Three state-certified autistic support teachers were assigned to the same classroom along with paraprofessionals assigned to assist individual students. The teachers and paraprofessionals agreed to participate in the study. Written informed consent of the parents and the participating students was obtained, as well as, permission from the classroom teachers and the school district for the study to take place. The university Institutional Review Board (IRB) of the primary investigator reviewed and approved the study.

Prior to the intervention, participants completed a one-minute mathematics progress paper based on their individual learning needs. The three autistic support teachers spaced the
students away from one another to complete the math progress paper. The lead teacher reviewed the expectations and directions before allowing the students to work on the one-minute assignment.

After the baseline for mathematical performance was established during the first four days of the study, the students participated in structured physical activity for 13 consecutive school days. This structured activity was in addition to the regularly scheduled, adapted physical education classes for these students (two days within a six-day cycle). In the 13-day structured physical routine from 9:30-9:45 each morning, participants engaged in aerobic dancing using an instructional DVD, immediately followed by stopping and counting to 20, as a cool down activity.

Following the cool down activity, participants alternated between two teacher-monitored stations for five minutes at each station. One station was designed for students to engage in gross motor skills. These activities included (a) crawling through a tunnel, (b) bouncing on a trampoline, (c) bouncing on a large stability ball, (d) using a roller, and (e) using a balance board. The second station was designed for improving tactile and fine-motor skills. These activities included manipulating beans, blocks, fidgets, and magnets. Immediately after working at the two stations, all six students completed another one-minute math progress paper.

After 13 days of the structured physical intervention, a reversal phase was implemented. In the four-day reversal phase, the sensory integration treatment activities at the two motor skills stations and aerobic dancing exercises were withdrawn (Kazdin, 1982). Trend data on math progress was collected to assess changes during the reversal phase.

Each participant completed the one-minute math paper under the careful supervision of certified classroom autistic support teachers and paraprofessionals assigned to the classroom. Throughout the study, the lead teacher maintained a daily log of critical incidents, which included participants’ focused engagement on physical activities and math progress papers. This enabled investigators to evaluate the potential influence of critical incidents on the math progress data.

Instrumentation

Based on the ABAB single-case research design (Kazdi, 1982) used for this project, an initial baseline was established for beginning math level data of six elementary-aged students with ASD. Daily mathematics progress tasks were aligned with assessment instruments, which were part of a package of special education assessment tools used by the local school district with this student population. The participating school district used a comprehensive proprietary assessment, which aligns with the state’s math standards. The instrument in the study was designed to assess multiple criteria on a student's individual instructional level and plan instruction based on data collected. Along with the local assessments, other assessments used by this district for similar purposes, include DIBELS, G-Made, 4-Sight, and state achievement exams, all collected annually and analyzed, in order to plan instruction and measure student achievement. Based on a student's current instructional level, the participating teachers were able to evaluate multiple sources of formative and summative data to measure academic outcomes of the intervention treatment in this study. This enabled teachers to determine the appropriate math levels to begin the study for each of the six participating students.
Results

Trend analysis graphs display mathematical progress results in Figures 1-6, showing all six of the participating students with ASD consistently improved academic work from the beginning of the study. It also shows math performance level decreasing for five of the six participants in at least one of four days during the reversal phase and increasing again when treatment was reapplied. Blank spaces in the graphs reflect days participating students were absent during the study. However, due to few absences, the data trends were not impacted. See Figures 1-6.
Figures 1-6.
*Daily Math Progress of Six Students with ASD During Intervention Study.*
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**ASD #3**

Math Scores vs. Daily Sessions

**ASD #4**

Math Scores vs. Daily Sessions
When analyzing the figures for each participant in relation to the critical incidents for each day of the study, represented in Table 1 (below), it is possible to determine patterns in math trends for each of the participating students with ASD. The analysis of the graphs in the figures and the tables for each participant aligns with improvements and declines in the daily math progress trend patterns.

Participant #1 scored lower in each of the days of the baseline phase, but seemed to improve each day except for one during the intervention phase. By looking at the table of critical incidents, this participant was distracted by the same peer on days three and four, which might have contributed to the continued decline in math progress. However, when examining the table of critical incidents more closely, it is appears evident few incidents occurred that affected math progress, except during day seven, when the participant was in time out for misbehavior. This
coincides with the major decrease in math progress during the intervention phase for this participant. After that incident, the participant maintained progress at a much higher level than at the beginning of the study.

When analyzing the table and graph for Participant #2, the improvement was sustained for the most part throughout the study following day five. Few incidents were recorded from that point in the study and this participant ended the intervention phase much higher than at the beginning of the study.

For Participant #3, few incidents were recorded and the level of math progress ended at a higher level compared to the beginning of the study. The patterns seemed to stay consistently high with the exception of a few days.

For Participant #4, the large decrease during baseline phase coincided with a humming episode, which the lead teacher described as “distraction.” The trend data patterns do not confirm any impact of the intervention for this participant, but math progress improved by the end of the study.

For Participant #5, math progress improved by the end of the study. However, so many incidents occurred for this participant, as demonstrated in the pattern of math progress. The result on day nine indicates the participant was on medication, active on the trampoline, and wide-awake. This coincides with an unusual spike in math trend data indicated on the graph.

For Participant #6, no negative incidents occurred during the entire study and this participant’s math progress pattern shows a sustained improvement in math at a much higher level than when starting the study. During the withdrawal phase, the math progress decreased slightly and then rose again when interventions were renewed.

Table 1.

Daily Critical Incident Report During ASD Study.

<table>
<thead>
<tr>
<th></th>
<th>ASD #1</th>
<th>ASD #2</th>
<th>ASD #3</th>
<th>ASD #4</th>
<th>ASD #5</th>
<th>ASD #6</th>
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<tbody>
<tr>
<td>Baseline</td>
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<tr>
<td>Day 1</td>
<td>Continually spoke out but worked-said what number he was to write</td>
<td></td>
<td>Cut top of paper off so it didn’t side track him</td>
<td>Fixated on erasing his mistake and could not get passed it</td>
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<tr>
<td>Day 2</td>
<td>When timer went off started erasing work</td>
<td></td>
<td>(after finished fixated on how Noah did) Competition hummed the whole minute, seemed distracted</td>
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<td>Day 3</td>
<td>Did well at first but saw</td>
<td>Absent</td>
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<tr>
<td>Day</td>
<td>Activity Details</td>
<td>Behavioral Observations</td>
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<td>Day 4</td>
<td>Worked correctly until he heard us prompt peer not to trace, then he began tracing</td>
<td>Began just circling had to prompt to write-on and off meds past 2 weeks</td>
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<td></td>
<td></td>
<td>In class when completed minute paper</td>
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<td></td>
<td></td>
<td>Prompted not to trace</td>
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<tr>
<td>Day 5</td>
<td>Loved the activities, very active, had to be reminded of directions for paper</td>
<td>Very moody, did not want to dance, kept prompting but not a lot of activity on his part, started out by circling prompted to write He erased then did correctly Reminded of directions for paper</td>
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<td></td>
<td></td>
<td>Did not dance, was in class</td>
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<tr>
<td>Day 6</td>
<td>Very active</td>
<td>Very active today *in time-out earlier in day, reviewed what to do prior to beginning</td>
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<tr>
<td></td>
<td>More active</td>
<td>Very active, hummed whole time Seemed real “off”</td>
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<tr>
<td></td>
<td>Medium activity level</td>
<td>Little activity, reviewed what to do prior to beginning</td>
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<td>Day 7</td>
<td>Not able to dance, in time-out then had to finish morning work</td>
<td>Did not dance-was at speech class</td>
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<td></td>
<td></td>
<td>Needed prompting</td>
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<tr>
<td>Day 8</td>
<td>More activity</td>
<td>Complained first 10-20 seconds of working</td>
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<td>Day 9</td>
<td>Got scratched at dance time and would not</td>
<td>Increased meds, falling asleep,</td>
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<tr>
<td></td>
<td></td>
<td>Very active</td>
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</table>
Discussion

Due to varied characteristics, skills, dispositions, and abilities among students with ASD, it is difficult to generalize specific strategies to help students with ASD use physical activity and physical education to improve academic performance. However, results from this particular modified single-case ABAB study provide insights that demonstrate benefits of daily structured physical activity combined with scheduled school physical education class for students with ASD. Results for all participants with ASD showed an overall improvement in math progress in this study, from beginning to end. It demonstrated additional structured sensory-related physical activity could help students with ASD perform academic work in a more focused manner. The research of Everhart, et al. (2012) indicates similar benefits for elementary-aged students with intellectual disabilities. The positive outcomes associated with physical activity and intellectual disabilities indicate the importance of providing structured physical activity for students with ASD (Castelli, Hillman, Buck, & Eri, 2007).
In considering the results of the 13-day intervention, using structured physical activity, two sensory-related stations, and aerobic dance, the graphs for five of six participants show a pattern of improvement in math progress immediately following the interventions. While one participant improved from start to finish, no clear sustained improvement during the intervention for that particular student was evident. This is possibly due to the diverse characteristics and needs of students with ASD. In examining the table of critical incidents, the same student struggled frequently with distractions during the study, which indicate the distractions potentially limited focus during completion of the daily one-minute math paper. Apart from this student, the graphs of the other students seem to indicate an upward spike in math progress from the onset of the intervention to the withdrawal phase. Since five of the six participants sustained higher-level math performance during the second four-day intervention after the withdrawal phase, it appears structured treatment had a positive effect on math progress for five of six participants, during the intervention.

While research is inconclusive (Castelli, Hillman, Buck, & Eri, 2007; Dawson & Watling, 2000; Smith, et al., 2005), it is clear during the intervention phase in this study, sensory activities combined with structured aerobic activity improved and sustained the math progress of five of six of students with ASD. Future research should continue to include larger numbers of participants with ASD for broader generalization.

With the wide variety of characteristics and needs of individuals with ASD, it will be challenging to pinpoint or generalize specific strategies to use with all students with ASD. However, the findings in this study are promising in that they support recent findings of Everhart and his colleagues (2012). According to Everhart, et al. (2012), brain focus is indicated to play a significant role in improved academic progress of elementary students with intellectual disabilities following structured aerobic dance intervention. Research outcomes suggest that autistic support classroom teachers and adapted physical educators work together to identify ways to increase structured physical activity in combination with aerobic activity and sensory-related stations for elementary students with ASD.
References


