Physical Activity and Cognitive Ability in Children with Autism Spectrum Disorder

By
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A THESIS

submitted to

Oregon State University

University Honors College

in partial fulfillment of
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degree of

Honors Baccalaureate of Science in Exercise and Sports Science
(Honors Associates Degree)

Presented May 27, 2016
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Autism Spectrum Disorder (ASD) is described as a developmental disability characterized by impairments in social interaction, communication, and repetitive or restricted movements. It has been shown that as children with ASD age, their cognitive and social skills improve with time, and physical activity has been linked with improving aspects of cognitive ability. This study looked at the correlations between physical activity, IQ, and age on 21 children with diagnosed ASD. Participants were given cognitive assessments in the form of an IQ test, and ratio IQ scores were calculated for both verbal and non-verbal IQ. Physical activity data was collected using an accelerometer, calculating how many minute per day each participant spend in sedentary, light, and moderate vigorous activity. Results showed a positive correlation between light physical activity and both verbal and non-verbal IQ, as well as a negative correlation between light physical activity and age. With the significant positive correlation found between light physical activity and both verbal and non-verbal ratio IQ, it is possible that light physical activity may be a predictor of cognitive ability in children with ASD, and a malleable intervention point.

Key Words: Autism Spectrum Disorder, Physical Activity, Cognitive Ability, IQ

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Nicole Brooke Johnson, Author

Introduction

Autism Spectrum Disorder (ASD) is considered one of the fastest growing developmental disabilities in the world (Frasier-Robinson, 2015). According to the Centers for Disease Control and Prevention's (CDC) *Mortality and Morbidity* weekly report, the prevalence of ASD has increased from a 1/150 persons in the year 2000, to 1/68 persons in the year 2010 (2014). ASD is described as a developmental disability characterized by impairments in social interaction, communication, and repetitive or restricted movements (American Psychological Association, 2013). Reliable ASD diagnoses can occur as early as 12 months, however, many children with ASD do not get diagnosed until much later in their life (Centers for Disease Control and Prevention, 2014; Osterling, Dawson, & Munson, 2002). Physical activity is an important factor for health, in children with and without disabilities, as it reduces risk for many health related diseases, such as heart disease, diabetes, and obesity. However, for children with ASD, physical activity can bring about additional benefits. It is important for children with ASD to participate in physical activity because it has been shown that physical activity can increase cognitive ability by increasing positive social behaviors, and decreasing negative behaviors (Aksay & Alp, 2014; Bremer, Crozier, & Lloyd, 2016; Lang et al., 2010; Powers, Thibadeau, & Rose, 1992; Reid, Factor, Freeman, & Sherman, 1988; Sowa & Meulenbroek, 2012).

Children with ASD often begin facing social delays and deficits as early as 12 months of age. One of the first significant delays, noticeable in children with ASD, is language delay (Luyster & Lord, 2009; Osterling et al., 2002). Theories suggest that this language delay could be due to the significance of social cues involved when children are

learning new words, and the lack of ability children with ASD have to recognize these social cues. When young children are in the process of learning new words, theories suggest that children often learn through watching their parents or caregivers facial expressions, lip movements, and emotions (Luyster & Lord, 2009). Children with ASD often face deficits such as, avoiding eye contact, difficulties relating to others, inability to understand other's feelings, and trouble adapting to changes (CDC, 2014). Due to these deficits, children with ASD are less likely to watch the facial expressions, lip movements, and emotions of their parents or caregivers, resulting in the early language delay so often seen in children with ASD (Luyster & Lord, 2009). Some research has shown that early diagnoses can be attained by looking at three specific cognitive impairments called the triad of impairments. This triad includes lack of eye gaze monitoring, lack of pointing and showing, and lack of pretend play (Frith, 1998). However, specific signs and symptoms of ASD can vary from child to child in both severity and type (CDC, 2014).

Due to the variation in signs and symptoms children with ASD can experience, they can also show a variation of associated features. One common associated feature of ASD is a lower than normal intellectual quotient (IQ) (Lloyd, MacDonald, & Lord, 2013). IQ generally improves with age; therefore testing the IQ of children with ASD can be a good indicator of how children are progressing. IQ tests have both a verbal IQ and a non-verbal IQ component. When these two components are put together they create what is called a composite score. Due to known communication deficits in children with ASD, they commonly have a lower verbal IQ score than children who don't have ASD (Lloyd et al., 2013). Therefore, the non-verbal component can be a better indicator of underlying IQ in children with ASD, and can be a good indicator of cognitive ability.

Physical activity interventions have been shown to increase cognitive abilities in children with ASD through increasing positive social behaviors, and decreasing maladaptive behaviors (Aksay & Alp, 2014; Bremer et al., 2016; Lang et al., 2010; Powers et al., 1992; Reid et al., 1988; Sowa & Meulenbroek, 2012). Research has shown that there is a correlation between children with ASD's physical ability and cognitive ability (MacDonald, Lord, & Ulrich, 2013). Research by MacDonald and colleagues analyzed young children with positive diagnoses of ASD. In the study, researchers measured fine and gross motor ability in participants and used those measurements to calibrate autism severity scores. Through this research, it was shown that children with ASD who had greater physical impairments, including weaker fine and gross motor skills, had greater cognitive impairments, and a more severe ASD diagnoses (MacDonald et al., 2013). The relationship in this study between physical impairments and cognitive impairments puts emphasis on the importance of early physical activity interventions, as physical activity interventions help improve both physical and cognitive ability (Lloyd et al., 2013).

Research has shown, with early physical activity interventions, there can be an increase in positive social behaviors in children with ASD (Bremer et al., 2016; Sowa & Meulenbroek, 2012). A meta-analysis done by Sowa and Ruud looked at different studies that all had the same 4 criteria. The studies had to include children or adults with ASD, physical activity interventions, cognitive variables that were quantitative in nature, and be published between 1991 and 2011. Their analysis included 16 different studies with a total of 133 participants. They found, overall, social abilities were improved in participants with ASD when physical activity programs were introduced, with a tentative

finding that people with ASD benefit more from individual physical activity programs rather than group programs (Sowa & Meulenbroek, 2012). From this study it can be concluded that physical activity interventions in children with ASD positively influence social behaviors.

A similar study, done by Bremer, Crozier, and Lloyd (2016), examined 13 different peer reviewed articles which looked at the effect that physical activity had on cognitive abilities in participants diagnosed with ASD. The studies included physical activity interventions such as horseback riding, swimming, yoga, dance, martial arts, and jogging. In the researchers' analysis, it was shown that all the analyzed studies found a significant increase in socio-emotional functioning, cognitive behaviors, and attention span, when physical activity interventions were implemented. The study also found a significant decrease in stereotypical behaviors (repetitive movements of the body or objects) when children with ASD participated in some form of physical activity (Bremer et al., 2016). Although it is easily derived that physical activity interventions benefit children with ASD in social facets, physical activity also helps decrease the maladaptive behaviors that many children with ASD often face.

Along with social deficits, children with ASD can often exhibit maladaptive behaviors, such as aggression, self-harm, and temper tantrums (CDC, 2014). Physical activity interventions in children with ASD have been shown to significantly decrease these negative behaviors (Aksay & Alp, 2014; Lang et al., 2010; Powers et al., 1992; Reid et al., 1988). In a case study done by Powers and colleagues (1992), an eight year old boy was exposed to ten minutes of roller skating physical activity before a structured play setting. Before the physical activity intervention, the child had high self-stimulatory

behaviors (repetitive movements of the body or objects), as well as high off task behaviors. After the ten minutes of physical activity, when participating in structured playing, the child had significant decreases in both self–stimulatory and off task behavior. A comparable study by Reid and colleagues (1988) looked at the effect of physical activity on three adolescent boys, in regards to maladaptive behaviors. The participants were measured daily during a baseline (pre-activity), physical activity, and return to baseline (post-activity) phase. The physical activity intervention included muscle toning and stretching, such as arm circles, bicycling, toe touches, and sit-ups. The results showed that with the three adolescent boys, an increase in physical activity was correlated with a decrease in maladaptive and stereotypical behaviors associated with ASD, and an increase in on-task behaviors. The results also concluded there are benefits of implementing physical activity programs for children with ASD at any age, and highlighted the importance of physical activity interventions to gain the cognitive benefits at early ages.

In an additional study conducted by Lang and colleagues (2010), 18 different studies were analyzed, looking at the effect of physical activity interventions on children with diagnosed ASD. The analysis included 64 total participants ranging in age from 3-41 years old. The analysis found that with regular physical activity, including activities such as jogging, bike riding, and weight training, children and adults with ASD showed a decrease in maladaptive behaviors. This included a decrease in stereotypical, aggressive, and off task behavior. The analysis also found that along with a decrease in maladaptive behaviors, there was an increase in positive behaviors. These positive behaviors included appropriate motor behaviors, such as playing catch and performing proper actions when

asked, and improved academic behavior, such as focusing in the class room and finishing assignments.

A similar study, done by Aksay and Alp (2014), analyzed the effect that physical activity interventions had on decreasing severe crises in children with ASD. Their study included 23 male and female children diagnosed with ASD, who had an average of 11.6 severe crises per week. The children participated in three 50 minutes sessions of exercise each week for 36 weeks. Upon completion of the study, the researchers concluded that with 50 minutes of physical activity at an average of three times per week, motor skills in the children with ASD were maintained, and the severe crises were almost eliminated. Taken together, these studies suggest that physical activity interventions are effective in decreasing many different maladaptive behaviors. While it can be derived that physical activity interventions are important for the cognitive and physical abilities of children with ASD, many children do not receive the physical activity interventions they need.

Despite the cognitive benefits physical activity can bring, children with diagnosed ASD are not meeting recommended daily values for physical activity (Obrusnikova & Cavalier, 2010). In a study by Obrusnikova and Cavalier (2010), factors that contribute to the lack of physical activity in children with ASD were analyzed. The study found that children with ASD are failing to meet the recommended amounts of daily physical activity because of many different factors encompassed in different domains. These domains include intrapersonal, interpersonal, physical, community, and institutional. The researchers found that the most common barriers to physical activity included wanting to play on electronics rather than exercise, lack of the physical skills to participate in a given physical activity, lack of a friend or parent to exercise with, and lack of an appropriate

activity to join in their community. Therefore, when trying to implement physical activity intervention programs, it is imperative that the barriers children with ASD face are taken into account.

A similar study, completed by Memari and colleagues (2015), looked at the prevalence of physical activity in 83 children with an ASD diagnosis with ages ranging from 6-15 years. Through the analysis it was found that of the 83 children only 10 (12% of the sample) were regularly physically active. A reason for this finding could be that due to social deficits associated with ASD, as children with ASD tend to choose to participate in solitary play rather than social play. This decision can lead to a more sedentary lifestyle. The study also looked at other reasons that children with ASD tend to be more solitary, and found that financial burden and lack of opportunities were leading barriers to lack of physical activity (Memari et al., 2015). These results are consistent with the results of the study by Obrusnikova and Cavalier.

How physical activity mediates the relationship between age and cognitive abilities in children with ASD has not been extensively studied. We know that as children grow, their cognitive abilities improve with age. When children are diagnosed with ASD at early ages, expedient intervention is important in aiding these children to achieve the best lives they can (Dawson et al., 2010). We hypothesize that increased physical activity behavior will mediate relations between age and cognitive abilities. We expect that when we look at physical activity, IQ, and age data on a range of children on the autism spectrum we will see that better physical activity behavior helps the relationship between age and cognitive ability in children with ASD.

Methods

Participants and Procedures

A convenience sample of children with ASD (n=21), between the ages of 4-17 years (mean age 10.58, SD 4.29) were recruited for descriptive research projects focused primarily on motor skill development and physical activity of children with disabilities. This data was collected based on continuous data collection methods at different times throughout a given year (e.g. spring, summer, fall, and winter). Descriptive information about these participants can be found in Table 1. In general, all participants were recruited for these studies through ASD or disability support groups, community-based programs, and health related or rehabilitation offices. All parents or caregivers signed an informed consent prior to participating in any study activities, and all participants assented to take part in the study. In this cross-sectional study, all participant assessments took place within a short period of time, usually over the course of one to two days. However, physical activity data was collected over a one week period for each participant. The institutional review board at Oregon State University approved all study procedures.

Cognitive Assessment

Developmental level was assessed based on one of three assessments, the Mullen Scale of Early Learning (MSEL), the Stanford Binet 5th edition, and the Differential Abilities Scale. Each participant was given one of the three IQ tests based on age and verbal abilities. The MSEL is a way of testing cognition in children with ASD. The MSEL can be given to children and infants from 0-68 months (0 years -5 years 8

months). The MSEL consists of 5 scales, gross motor, visual reception, fine motor, expressive language, and receptive language. The gross motor scale, from the MSEL, is not included in the early learning composite score. For each scale, one can get individual T-scores, percentile rankings, and age equivalents. The gross motor scale includes things like running, walking, jumping, etc. The visual reception scale includes visual localization, tracking and scanning. The fine motor scale includes hand eye coordination, motor planning and control. The expressive language scale includes verbal expressive abilities like using phrasing, and comprehending sentences. The receptive language scale includes auditory discrimination and auditory and motor ability, including things like understanding action words, and understanding left from right (Mullen, 1995).

The Stanford Binet 5th Edition assessment measures cognitive ability in individuals ranging from ages 2 to mature adulthood. The Stanford Binet assessment looks at 5 factors of cognitive ability, fluid reasoning, knowledge, quantitative reasoning, visual-special processing, and working memory. The test works to help diagnose developmental and intellectual deficits in children. There are 10 subset scores, and two domain scales, a non-verbal IQ scale and a verbal IQ scale. The non-verbal IQ scale contains the 5 non-verbal subset scores, the verbal IQ score contains the 5 verbal subset scores, and the full IQ contains all 10 subset scores (Roid, 2003).

The Differential Abilities Scale measures cognitive ability and achievement levels for children ages 2 years 6 months to 17 years 11 months. Due to the large age range of the test, the ranges are broken up into three groups, the preschool level, the school-aged level, and the school achievement level. The test consists of 20 subtest, 17 for cognitive and 3 for achievement. The General Conceptual Ability (GCA) makes up the cluster

score, which includes verbal, spatial, and nonverbal reasoning abilities. Special ability scores for verbal and nonverbal reasoning ability and special ability can be written as standard scores or percentiles (Elliot, 2007).

Ratio IQ's were calculated to standardize IQ scores across the range of tests. To calculate verbal ratio IQ, the mean age equivalent of the expressive and receptive language subtests are divided by the chronological age of the participant and then multiplied by 100. The ratio non-verbal IQ was calculated the same way, with age equivalents from fine motor and visual reception subtest rather than the language subtests. This method was used in others studies as well (Lloyd et al., 2013; Tyler, MacDonald, & Menear, 2014).

Physical Activity Assessment

Physical activity was measured over a seven-day period using accelerometers placed on the participant's right hip using an elastic belt. This is a reliable and valid measure of physical activity for children with disabilities (Kim & Yun, 2009). All participants were asked to wear the accelerometer for all waking hours of the day. The monitor was to be worn for all activities except swimming, showering or bathing, and sleeping, and was recorded in self-report logs by parents or caregivers. Parents or caregivers were instructed to record, in the self-report logs, any times in which the monitor was not worn (i.e. forgetting to put it on, taking it off for comfort, or any other reasons it may have been removed). Accelerometer data was compared to parent's logs and reduced to four categories, sedentary, light, moderate, and moderate to vigorous physical activity. These categories were derived from preset cut-points. Data was reduced

to average times spent in each physical activity category, as described above (Tyler et al., 2014).

Data Analysis

All analyses were conducted in SPSS version 23. Descriptive variables were calculated with means, standard deviations, and frequencies as appropriate. A Pearson bivariate correlation was used to determine initial relations between independent and dependent variables.

Results

A total of 21 participants (n = 16 males and n= 5 females) between the ages of 4 and 17 (mean = 10.58 years) all with diagnosed ASD were included in this study. Descriptive statistics are shown in Table 1. There was a significant negative correlation between age and light physical activity, as well as a positive correlation between age and moderate physical activity. There were significant positive correlations between light physical activity and both verbal and non-verbal ratio IQ. There was also a significant negative correlation between age and verbal ratio IQ. These correlations can be found in Table 2.

Discussion

One of the most interesting findings in this study was the positive correlation between light physical activity and verbal and non-verbal ratio IQ. This study also found older children with ASD displayed less light physical activity, yet more moderate vigorous activity. It is important to note that this study showed that the participating

children had a negative correlation between age and IQ, and a negative correlation between age and light physical activity, meaning the older children had lower IQ, and less light physical activity than younger children. With the significant positive correlation found between light physical activity and both verbal and non-verbal ratio IQ, it is possible that light physical activity may be a predictor of cognitive ability in children with ASD, and a malleable intervention point.

This study also found that age has a negative relationship with verbal IQ in children with ASD, where older children tended to have lower verbal IQ sccores. This is consistent with findings done by Lloyd and colleagues (2013). Their study showed that due to known deficits in verbal communication in some children with ASD, non-verbal ratio IQ is a better indicator of actual IQ than verbal IQ (Lloyd et al., 2013). This is consistent with this study where there was found to be a significant negative correlation between age and verbal ratio IQ, but no significant correlation between age and non-verbal ratio IQ.

In a study by MacDonald and colleagues (2013) it was found that cognitive ability and physical activity were inherently linked in children with ASD. MacDonald and colleagues' research showed that in children with ASD, those with higher physical impairments had higher cognitive impairments (MacDonald et al., 2013). These results are consistent with the results from this study, where a positive correlation was seen between cognitive ability (both verbal and non-verbal ratio IQ) and light physical activity.

The significant negative correlation between age and light activity is one result from this study that is consistent with multiple previous studies. Studies done by Obrusnikova and Cavalier (2010), and Memari and colleagues (2015), both found that a majority of children with ASD are not meeting recommended values for physical activity, due to many factors, including physical impairments, social deficits, and outside influences (Memari et al., 2015; Obrusnikova & Cavalier, 2010). Light physical activity may be more compatible with the lifestyle of children with ASD, due to known physical impairments some children with ASD face. Finding that older children with ASD are receiving low levels of light physical activity is expected, but should not be the normal.

Due to the positive correlation between physical activity and cognitive ability, coupled with the lack of physical activity that children with ASD receive, it is increasingly important to implement early intervention programs that focus on physical activity (Aksay & Alp, 2014; Bremer et al., 2016; Lang et al., 2010; Memari et al., 2015; Obrusnikova & Cavalier, 2010; Powers et al., 1992; Reid et al., 1988; Sowa & Meulenbroek, 2012). Early physical activity interventions have been shown to help improve physical ability, and thus cognitive ability in children with ASD (Lloyd et al., 2013). Due to the results found in this study, it is recommended that early physical activity intervention programs should focus on light activity rather than moderate-vigorous activity, because light physical activity has been shown to increase both verbal and non-verbal ratio IQ in children with ASD.

Limitations

Limitations to this study include unequal sample sizes of male and female children. However, the sample sizes (male n=16, female n=5) are consistent with the current prevalence ratio of 5 males: 1 female in children with ASD (CDC, 2014). Another limitation to this study was the small sample size. Additional studies with larger sample sizes are needed in the future.

Future Direction

Future studies with larger sample sizes should be done to determine any mediating variables involved in the interrelationship of IQ and physical activity. Further studies could be done to determine the best type of physical activity intervention that would strengthen the positive correlation between physical activity and cognitive ability.

Table 1

Descriptive Statistics of Participants

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	21	4.04	17.02	10.58	4.29
Sedentary Activity (minutes/day)	21	262.1	664.5	423.61	106.51
Light Activity (minutes/day)	21	41	300.83	148.03	84.12
Moderate Vigorous Activity (minutes/day)	21	31.5	340.3	139.28	84.01
Verbal Ratio IQ Score	20	16.32	110.09	63.56	28.74
Non-Verbal Ratio IQ Score	21	16.4	138.73	64.72	30.3

	Frequency
Gender	
Male	16
Female	5
Secondary Disabilities	
None	8
Asthma	5
FAS	1
Multiple	4
ADHD	1
Other	1
Ethnicity	
Caucasian	17
Latino/Hispanic	1
Mixed	3

Table 2

Descriptive Statistics Correlations

	Age (years)	Sedentary Activity	Light Activity	MV Activity	Verbal Ratio IQ	Non Verbal Ratio IQ
Age (years)	--					
Sedentary Activity	0.362	--				
Light Activity	-.844**	-.605**	--			
Moderate Vigorous Activity	.502*	-.282	-.413	--		
Verbal Ratio IQ	-.568**	-.301	.595**	-.151	--	
Non Verbal Ratio IQ	-.433	-.153	.529*	-.246	.764**	--

** Correlation is significant at the .01 level (2- tailed)

* Correlation is significant at the .05 level (2-tailed)

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