

Effect of Physical Activity on the Stereotypic Behaviors of Children With Autism Spectrum Disorder

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Abstract

Background: Physical activity is now widely accepted as a measure to reduce stereotypic behaviors in children with Autism Spectrum Disorder (ASD). However, several issues exist concerning the effects of physical activity on stereotypic behaviors, such as inconsistency with research methodology. The present study which was different from previous investigations as it attempted to address those issues because it classified the intensity of physical activity using heart rate, monitored the children's behavior over a span of 4 hours after physical activity and documented how long stereotypic behavior reduction lasted. The regimented exercise routine was also enriched with fun and motivational activities.

Objectives: The purpose of this study was to examine the effects of physical activity on stereotypical behaviors of children with ASD.

Patients and Methods: The present study was comprised of 23 children aged from 5 to 11 years, who participated in 15 minutes of moderate to vigorous physical activity (MVPA). Physical activity was identified as moderate or vigorous based on the child's heart rate. Participants were observed for a period of 2 hours before and after 15 minutes engagement in MVPA and their behaviors were then classified as either stereotypic behavior (SB) or task-engaged behavior (TE). A 2 (gender) x 3 (disorder) repeated measures ANOVA was conducted on pre and post percentage scores to analyze the physical activity effects on children's stereotypic behaviors.

Results: A significant reduction in stereotypic behaviors of children with ASD was observed for 2 hours, following 15 minutes of MVPA.

Conclusions: This information has implications for researchers and practitioners who consider MVPA participation when designing behavior-changing interventions for children with ASD.

Keywords: Children, Autism, Physical Activity Intensity, Stereotypic Behaviors

1. Background

Autism Spectrum Disorder (ASD) is a neurological disease affecting about 1 in 88 U.S. children (1). ASD is usually diagnosed during childhood and is characterized by some core symptoms that include qualitative impairment in social interaction, delays in the development of communication, restrictive interests, and repetitive body movements. ASD includes Asperger syndrome, autistic disorder, and pervasive developmental disorder not otherwise specified (PDD-NOS) (1). To date, there is no cure or consistent known means of treating the symptoms (2). Several interventions are typically used for ASD treatment such as occupational therapy, horseback riding, medication, and applied behavior analysis (2, 3). All of these interventions are usually focused on attempting to reduce stereotypic behaviors in children with ASD because these types of behaviors can be extremely disruptive in classroom, playground, home, and other social situations (2).

Because ASD is classified as a sensory disorder, it is believed that the stereotypic behaviors associated with ASD are an attempt on the individual's part to provide him or

herself with sensory feedback (4). These stereotypic behaviors are self-stimulatory, non-functional, and repetitive in nature and can take the form of rocking, hand flapping, and gazing (2-6). Therefore, it is difficult to achieve a reduction in stereotypic behaviors. On the other hand, the reduction of these stereotypic behaviors is important because they are often inappropriate and interfere with social and learning situations in children with ASD (2). Stereotypic behaviors may cause children to have anxiety when placed in social settings and can lead to apprehension or withdrawal from participating in group situations and interactions with others. Unwillingness to integrate socially can prevent a child from acquiring appropriate social, communication, and language skills (4).

Stereotypic behavior and maladaptive behavior are often associated with one another. Stereotypic behaviors are considered problematic because they reduce attention and interfere with the task at hand (7-10). When these stereotypical inappropriate behaviors occur in a social setting, they can result in frustration or

aggression in children interacting with peers or authority figures. Maladaptive behaviors include aggression, self-injury, or property damage (11). Oftentimes with a reduction in stereotypic behaviors, maladaptive behaviors also decrease because the child can better focus on the directions and tasks. Stereotypic behaviors prevent children from appropriately responding to their environment and interfere with the learned behaviors causing integration problems (5, 10). Furthermore, children with ASD who engage in stereotypic behaviors can be difficult to reach and oblivious to external stimulation (12). This creates a gateway for maladaptive behaviors to surface in a classroom or home setting when the child is unwilling to properly respond to his or her environment. Therefore, it is a priority to reduce stereotypic behaviors so that positive and adaptive responses can occur instead of maladaptive behaviors.

Physical activity is now widely accepted as a technique to reduce stereotypical and maladaptive behaviors in children with ASD (5, 6, 9, 13, 14). The earliest evidence for physical activity as a form of decreasing stereotypical and maladaptive behavior comes from the reports of special education teachers who stated that students with ASD appeared more attentive and cooperative after physical activities such as the gym, field trips, or outdoor physical activities (2). Many studies have looked at the effect of physical activity on the reduction of stereotypical behaviors (6, 15). In a review article, Lang et al. (3) reported that regular and specific types of physical activity could benefit individuals with ASD in regulating their stereotypic behaviors. Although physical activity cannot eliminate stereotypic behaviors, it may alter the response from inappropriate to appropriate. This alternation may lead to better behavior responses and a decrease in maladaptive behaviors for children with ASD (11).

The positive health benefits combined with its relative ease of implementation make physical activity a preferred strategy for behavior modification in children with ASD. Burns and Ault (2) suggested that the participants only needed to spend 5 - 8 minutes on the treadmill to yield favorable behavior results, supporting the idea that physical activity can be an easy form of intervention for children with ASD. Favorable behavior results typically means a decrease in the stereotypic behavior and aggression with heightened attention.

However, several issues exist concerning the effects of physical activity on stereotypic behaviors. One issue is that there is a lack of consistency on research methodology. Researchers use intensity terms such as mild, moderate, and vigorous physical activity without really defining the parameters that constitute each type of exercise (2, 3). Another issue is that there is a lack of research for how long the effect of physical activity lasts. Although, we know that physical activity can decrease stereotypical behavior, the duration of how long the child's stereotypic behavior decreases after engaging in physical activity is unknown. Finally, there are challenges to successfully motivating children with ASD to participate in physical activity (16-18). Our study addressed those issues and was different from the previous studies because we classified the intensity of physical activity using heart rate, monitored the children's behavior over a span of 4 hours before and after their physical activity participation to document the reduction effect, and incorporating fun and motivational activities into a regimented exercise routine.

2. Objectives

Therefore, the aim of this study was to examine the effect of physical exercise on the stereotypic behaviors of children with ASD and the duration of reduction in their stereotypic behaviors, induced by physical activity.

3. Patients and Methods

Participants were recruited from local schools and organizations. Twenty-three children aged 5 - 11 years (7 females and 16 males) participated in the study. All children were diagnosed by a psychiatrist or a licensed psychologist according to DSM-IV-TR (19). Eight children had a diagnosis of autistic disorder, seven children were diagnosed with Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), and eight children had a diagnosis of Asperger's Syndrome. Participants' demographic information is presented in Table 1. Each parent was briefed about the study and asked to sign a consent form prior to their child's participation. All children were given the opportunity to orally express their assent. The experimental protocol was approved by the Institutional Review Board of the local University.

Table 1. Demographic Information on the Participants' Mean Age, Gender, and Disorder

Autism Spectrum Disorder	Mean Age, y	Number	Gender	
			Male	Female
Asperger syndrome	7.0	8	6	2
Autistic disorder	7.5	8	5	3
PDD-NOS	8.3	7	5	2

Abbreviation: PDD-NOS, pervasive developmental disorder not otherwise specified.

All children were observed and screened for 2 hours before they were included in the study. Specific attention was given to document the child's behaviors, willingness to be active, and interaction with other children. The inclusion criteria were: 1) The children were capable of communicating with the investigators, 2) They were able to follow the instructions, and 3) They were willing to engage in the scheduled physical activities. In addition, parents of participants filled out detailed questionnaires concerning their child's stereotypical behaviors. These questionnaires were used in addition to observations that decided whether a child would be included in this study.

Children's behaviors were classified as "stereotypic" or "task-engaged" behaviors. Stereotypic behavior (SB) refers to the broad class of topographically similar behaviors linked by repetition, rigidity, invariance, as well as inappropriate behaviors in nature (20). Some stereotypic behaviors, for example, include body rocking, toe-walking, arm, hand or finger flapping, repetitive and self-stimulatory movements or vocal responses, and self-injuries (20, 21). Task-engaged behavior (TE) is defined as the child acting appropriately in the current situation while listening to the directions as well as interacting well with others. The screening information on stereotypic and task-engaged behavior was used as children's baseline data before their participation in physical activity.

Children's medical histories were also used to ensure that they could participate in physically demanding activities. Children that had been given limited physical activity orders by a physician were excluded from the study. Medical histories also revealed if participants were taking medication for their ASD. However, none of the participants needed medication administered during the observation period nor had any child started new medications. Therefore, medication effects were not analyzed in this study. All children in this study met the inclusion criteria.

3.1. Procedure

Several activity stations and centers were set up in a gymnasium. All activity centers were developmentally appropriate and engaging. During the data collection, all children were encouraged to be active and had a research assistant serving as a supervisor working one-on-one with them at all times. This assistant was responsible for getting the child to participate in moderate to vigorous physical activities (MVPA).

Several research assistants served as data collectors and were responsible for observing participants throughout the data collection. All research assistants were blind to the participant's diagnosis and the purpose of the study. The one-on-one supervisor administered the physical activity for each participant while being the data collector observed. The children chose the physical activity they liked. Certain activities were offered to the participants

based on the fact that they would raise the child's heart rate to the desired intensity level such as jumping on a trampoline, stationary biking, completing an obstacle course, and/or playing dance-dance revolution game. Several group activities were also provided such as red light-green light, parachute, and tag-of-war games. The goal was to encourage the child to participate in MVPA for 15 min. After the child selected and completed his or her physical activity period, the data collectors recorded the heart rate and intensity of activity, and documented the behavior the child displayed.

In a period of 4 hours, children were observed for 2 hours in 15 minutes intervals as baseline. After 15 min MVPA participation, children were documented and recorded as either engaging in SB or TE in 15 minutes intervals for 2 hours. During the physical activity period, participants were expected to interact appropriately with the supervisor, and to engage in moderate to vigorous intensity level exercise. When organized or group activities were planned, willingness to participate and ability to follow directions were also taken into account. Children were engaged in the same school tasks before and after the physical activity participation.

In general, if a child demonstrated any stereotypical behaviors that were deemed non-functional to the current setting, the supervisor would attempt to redirect the child to participate correctly in the activity. However, if the child screamed, hit, refused to follow directions, showed aggression, engaged in any activity that could damage property or result in a self-injury at any point during the 15 minutes, SB was recorded. SB can interfere with daily activities leading to maladaptive behavior when interacting with peers or authority figures. When the SB could not be redirected and led to maladaptive behaviors, the child also received a rating of SB. If the child was engaged in an appropriate activity, followed instructions, and had no instances of SB throughout the entire 15 minutes, a TE was recorded.

Heart rate was used to determine the intensity of physical activity. While the child engaged in physical activity, he or she wore a wrist heart rate monitor (Mio Energy Pro, Vancouver, Canada). Mio uses ECG information for accurate reading of heart rate. This heart rate monitor took a reading when the child applied his or her thumb to a sensor on the watch after the activity was over. Children were classified as engaging in moderate-intensity physical activity if their target heart rates were between 50% - 70% of their maximum heart rate. If children's target heart rates were between 70% - 85% of their maximum heart rates, they were classified as engaging in vigorous-intensity physical activity (22). The maximum heart rate was calculated by $208 - 0.7 \times \text{age}$ (23). Therefore, for a 5-year old child, his/her target heart rate for moderate physical activity is estimated between 102 - 143 beats per minute. Participants were encouraged to maintain their heart rates at a moderate to vigorous level during the 15 minutes physical activity.

The types of physical activity were designed with the idea that getting children with ASD to participate in physical activity can sometimes be challenging. The exercises used in this study were intended to appeal to children by having some aspects of play involved. For example, the stationary bike used in this study was equipped with a television screen that displayed a video game prompting the participant to pedal faster to win. Another game-like technique used to motivate the children to want to participate in moderate to vigorous activity was to provide the children with a dance pad game that made them use their feet to correspond to symbols displayed on a screen.

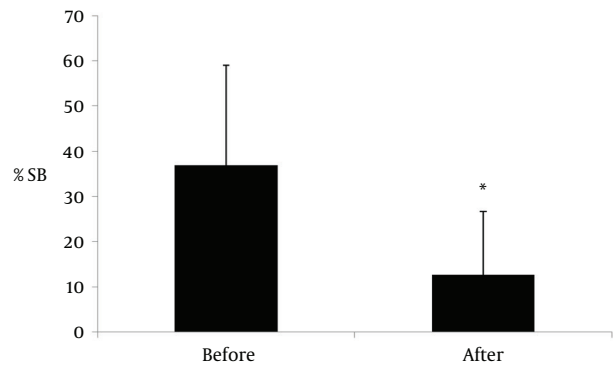
3.2. Data Analysis

Descriptive statistical analyses were used to describe the SB and physical activity intensity. Behavior data were collected and then transferred to quantitative data by finding the percentage scores of time the child spent participating in SB or TE. Percentage scores were determined based on number of 15 minutes intervals of SB versus number TE in the 2-hour block pre and post the 15 minutes MVPA. When maladaptive behaviors occurred due to a resistance to be redirected from SB, it was classified as SB. Many times the SB and maladaptive behavior would last through several 15 minutes intervals. The dependent variable was SB percentage score. A 2 (gender) x 3 (disorder) repeated measures ANOVA was conducted on SB percentage scores for before and after 15 minutes physical activity engagement. Results were considered significant if the alpha level was 0.05. In addition to statistically significant findings, effect size was determined for practical significance using Cohen's *d* (24).

4. Results

Parameters including duration and intensity were determined prior to investigation. All the children (100%) engaged in moderate to vigorous intensity level during physical activity participation. For a 4-hour observation period, results showed that physical activity reduction effect on stereotypic behaviors lasted for 2 hours for children with ASD. This was determined by comparing the baseline observation data with the post physical activity observation data, which were recorded in the same way using the 15 minutes intervals for SB or TE ratings. A repeated measures ANOVA analysis revealed a significant difference on pre and post percentage scores, $F(1, 17) = 7.523, P < .05$. No significant performance difference was found on gender, $F(1, 17) = 4.253, P > .05$, and disorder $F(2, 17) = 2.949, P > .05$. Means and standard deviations of children's SB percentage scores for before and after participation of physical activity are presented in Figure 1. These results suggested that participation in physical activity reduced stereotypic behaviors for children with ASD regardless of gender and types of ASD. About 15 minutes MVPA a day would significantly reduce children's stereotypic behavior for 2 hours.

Figure 1. Significant Reduction in Percentage Scores of SB Before and After 15 Minutes Moderate to Vigorous Physical Activity in Children With ASD



* Indicates significant difference.

The effect size describing exercise effects on children with ASD stereotypic behaviors between before and after physical activity participation was large ($d = 1.35$). The effect size result indicated that the true effect in the population might be considerable.

5. Discussion

The purpose of this study was to determine the effects of physical activity engagement on stereotypic behaviors in children with ASD and the length of time that the reduction effect would last. The results of this study indicated that only 15 minutes of MVPA participation helped children with ASD decrease the amount of stereotypic behaviors for 2 hours. This finding is consistent with several previous studies that found exercise to be beneficial to children with ASD stereotypic behaviors (5, 6, 9, 15).

The importance of our finding has some positive implications. First, stereotypic behaviors create a barrier to social integration and the severe behavior problems that can result in children being removed from the classroom (11). Physical education classes and recess can be used to help children with ASD to perform in the classroom because it raises children's heart rates and can result in a decrease in stereotypic behaviors, which may inhibit learning in the classroom setting. Secondly, parents can use this finding to help control their children's stereotypic behavior problems at home. By simply taking their child on a run, bike ride, or to the park for 15 minutes, they may see a significant decrease in SB at home that may last for 2 hours.

Another implication of this study is the advantage of the many health effects that exercise could have on children with ASD. Studies show that children with ASD are at risk for many health risks and nutritional deficiencies brought on by lack of exercise because they are not motivated to be physically active and they do not care about their selective diets (25, 26). This makes it difficult to get the children with ASD to engage in physical activity; however, our success in assisting children in choosing enjoyable physical

activities could help them to be more involved, active, and included in team sports and group activities. It is suggested that physical activity can be a method of preventative behavior management for children with ASD. Educators, therapists, and parents can use physical activity to address stereotypical behaviors before they start as an alternative to use medication or negative consequences after the maladaptive behavior occurs.

The results did not show a difference between gender and disorder. This suggests that most children with ASD can gain positive effects from MVPA because no specific exercise regimens need to be prescribed for children in different gender or disorder. This finding helps practitioners and educators in designing behavior treatment for children with ASD because MVPA may help decrease and limit stereotypical behaviors. This means that even just allowing children with ASD to participate in physical activities with their peers, benefits them twofold by involving them in social situations and helping them minimize stereotypical behaviors.

One limitation of this study was that each child was differently affected by their disorder, thus making it difficult to generalize how treatment options such as physical activity would affect each child's behavior. No significant gender and disorder difference was found in this study may be due to small sample size. In addition, we had a small group of female participants. It was difficult to match children with ASD in gender because the gender ratio in children with ASD is roughly five males to every female. Therefore, our findings can only be generalized to children with similar age, gender, and disorder. For future study, researchers could examine the effect differences arise between the two types of physical activity. That is, the differences between play-exercise (as done in this study) and traditional walking, jogging, or other structured exercise (done in previous studies). A comparison study will help us understand which type of physical activity will result in more reductions on stereotypical behaviors for children with ASD. It is also suggested to include a play group and a control group to better monitor the effects of physical activity on stereotypical behavior in future research.

The findings of this study significantly contributed to the literature by providing researchers and practitioners with parameters on exercise intensity and duration necessary to induce a reduction of stereotypical behaviors for children with ASD. Specifically, the methodology used in this study builds upon the previous studies by monitoring heart rate and amount of time engaged in physical activity. Future researchers can benefit from the prescribed methodology in designing studies, training programs and interventions. Secondly, the outcomes of this study add to the literature by demonstrating that changes in behavior can be influenced by providing enjoyable and self-directed physical activities, whereas previous studies have only employed prescriptive exercise such as jogging and walking. Lastly, the results of the current study add

to the literature by providing practitioners with practice guidelines to produce changes in stereotypical behaviors of children with ASD through MVPA. This knowledge is essential for researchers and practitioners to develop evidence-based training programs and interventions that effectively produce positive changes in children's stereotypical behaviors.

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Footnote

Authors' Contribution: Ting Liu developed the original idea and the protocol, abstracted and analyzed data, wrote the manuscript. Anne T. Fedak and Michelle Hamilton contributed to the development of the protocol, abstracted data, and prepared the manuscript.

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