Exercise and Autism Symptoms: A Case Study

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The current study employed a single-subject design to examine the effects of exercise on core autism symptoms in a 12-year-old boy. We recorded the frequencies of self-stimulation, eye contact, verbal initiation, negative mood, and positive mood before and after a 5- to 8-min mildly strenuous running intervention twice a week. In replication of previous autism research, the results revealed a significant postexercise reduction in self-stimulation across all 18 days of data collection. The intervention failed to produce significant improvements in the other 4 behaviors. A brief period of physical activity appears to be an inexpensive and easy method to decrease self-stimulation. Future autism research should further investigate the differential effects of various exercise durations on core autism symptoms.

Exercise and Autism Symptoms

Autism is a type of pervasive developmental disorder affecting all spheres of a child's life (Bauman & Kemper, 2006). The core diagnostic criteria of autism include a marked impairment in the ability to relate to others, delayed language, and restricted or repetitive patterns of behavior. No known cure or effective prevention measures currently exist. Major autism symptoms which are frequently targeted for improvement include self-stimulatory behaviors, infrequent eye contact, lack of verbal initiation, and unhappy mood. Typical interventions, such as applied behavioral analysis (e.g., Anderson & Romanczyk, 1999), occupational therapy (e.g., Sams, Fortney, & Willenbring, 2006), therapeutic horseback riding (e.g., Bizub, Joy, & Davidson, 2003), and pharmacological treatment (e.g., Findling, 2005), target these problem areas. A recent but understudied intervention for autism is physical exercise (Celiberti, Bobo, Kelly, Harris, & Handleman, 1997). The aim of the current study was to examine the effects of moderate physical activity on core autism symptoms.

Symptoms of Autism

Self-stimulation. The restricted or repetitive patterns of autistic behavior are often manifested through self-stimulation (Rosenthal-Malek & Mitchell, 1997). These characteristic stereotypic behaviors include body-rocking, hand-flapping, head-nodding, object-tapping, and sniffing. Repetitive vocalizations, such as song snippets or nonsense words, are also common (Schreibman, 2005). Stereotypic behaviors can be extremely disruptive in both educational and social settings (Celiberti et al., 1997).

Infrequent eye contact. One of the most useful behaviors for discriminating between children with autism and typically-developing children is impaired eye contact (Clifford, Young, & Williamson, 2007). Longitudinal studies have shown that this behavioral marker can distinguish children by 12 months of age who are later diagnosed with autism (Zwaigenbaum et al., 2005). Even beyond infancy and childhood, individuals with autism continue to show impairments in eye contact (Autism Speaks Inc., 2007).

Lack of verbal initiation. Another important diagnostic criterion for autism is impaired verbal communication (Voder & McDuffie, 2006). Even with treatment, approximately 35% to 40% of children with autism do not learn to speak as their primary mode of

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communication (Chan, Cheung, Leung, Cheung, & Cheung, 2005). Children who do talk usually begin speech by repeating other people's words, especially the last few words of a sentence (Wing, 1972).

Unhappy mood. The mood of a child with autism can be highly unpredictable (Wing, 1972). Temper tantrums are common, especially if a familiar routine is disrupted. Resistance to change often leads to an unhappy mood, shown through typical tantrum behaviors (e.g., crying, screaming, kicking). Some children exhibit severe tantrum behavior, throwing fits significantly greater in intensity and duration than tantrums of typical children (Schreibman, 2005).

Autism Interventions

Applied behavioral analysis. After several decades of treatment research for children with autism, applied behavioral analysis (ABA) remains the consistently preferred intervention (Autism Speaks Inc., 2007). This approach involves an objective measurement of behavior, an assessment of current functioning, an individualized curriculum, the systematic use of reinforcers, and the promotion of generalization. Hundreds of published studies have replicated the utility of ABA methods to help individuals learn specific skills, such as self-care, academic tasks, and communication (e.g., Lovaas, 1987; Schreibman, 2005).

Occupational therapy. According to Autism Speaks Inc. (2007), the aim of occupational therapy (OT) is to enhance an individual's independence and participation in meaningful life activities. For children with autism, OT normally addresses sensory issues such as over- or under-responsiveness to sensory stimuli (Sams et al., 2006). A second important focus of OT programs involves developing fine and gross motor skills (Stackhouse, Graham, & Laschober, 2002).

Therapeutic horseback riding. Therapeutic horseback riding, one of the more recent autism interventions, is a type of animal-assisted therapy (Bizub et al., 2003). Children perform exercises on a horse to target flexibility, equilibrium, reflex integration, and coordination (e.g., throwing and catching a ball). In addition to these physical benefits, therapeutic horseback riding can improve negative mood states and social interactions (All, Loving, & Crane, 1999; DePauw, 1986; Martin & Farnum, 2002).

Pharmacological treatment. Although no pharmacological treatment has proven effective for the overall core symptoms of autism, atypical antipsychotics and antidepressants can improve common secondary autistic behaviors, such as tantrums and self-stimulation (Findling, 2005; Hollander et al., 2005; McCracken et al., 2002). The most common side effect from medication is undesired weight gain (Potenza, Holmes, Kanes, & McDougle, 1999). Several studies thus emphasize the importance of diligently monitoring weight gain in medicated children, and they further suggest an exercise regimen to combat extra pounds (Malone, Cater, Sheikh, Choudhury, & Delaney, 2001; Martin et al., 2004).

Exercise. The earliest support for exercise as an autism intervention came from anecdotal evidence highlighting exercise as a technique for controlling self-stimulatory behaviors (Powers, Thibadeau, & Rose, 1992; Watters & Watters, 1980). Special education teachers reported that students appeared to be more attentive and cooperative after physical activity such as gym class, field trips, or other outdoor excursions. This early interest in the beneficial results of exercise led autism researchers to further explore the effects of physical activity on stereotypic behaviors. Overall, these studies touted exercise as a promising area of research for decreasing self-stimulation in individuals with autism (Celiberti et al., 1997; Elliott, Dobbin, Rose, & Soper, 1994; Gordon, Handleman, & Harris, 1987; Kern, Koegel, & Dunlap, 1984; Kern, Koegel, Dyer, Blew, & Fenton, 1982; Levinson & Reid, 1993; Lochbaum & Crews, 1995; Rosenthal-Malek & Mitchell, 1997; Watters & Watters, 1980). The physical activity must occur at sufficient intensity in order to decrease self-stimulation (e.g., Kern et al., 1982).

One possible explanation for the relation between strenuous exercise and decreased self-stimulation is that the physical intensity level simply exhausts people to the point that they are subsequently too tired to engage in physically active behaviors. If true, exercise would produce not only a reduction in stereotypic behaviors, but it would decrease positive behaviors as well. Several autism studies (Kern et al., 1982; Rosenthal-Malek & Mitchell, 1997; Watters & Watters, 1980), however, have ruled out this so-called "fatigue effect" by showing that exercise leads to a decrease only in disruptive behaviors, not to a general decrease in all behaviors, such as appropriate ball-playing.

Given the lack of support for the fatigue-effect explanation, recent studies have suggested alternative hypotheses for why exercise reduces self-stimulation. According to one theory, physical activity produces physiological arousal in a manner similar to self-stimulation, thus reducing the need for the inappropriate behavior (Allison, Basile, & MacDonald, 1991). According to another, exercise can provide sensory feedback similar to self-stimulation but in a more acceptable manner (Lovaas, Newsom, & Hickman, 1987).

A serious problem underlying the exercise and autism research literature concerns a lack of consistent methodology or design (Lochbaum & Crews, 1995). Although several studies have reported an encouraging relation between exercise and reduced stereotypic behaviors, the interventions have spanned different intensities and durations, and many researchers have used the adjectives "mild," "moderate," or "vigorous" to describe the prescribed exercise without clear operational definitions. Perhaps most striking is the gap in autism research concerning the effects of exercise on other variables. For example, no studies investigating the influence of jogging on self-stimulation have examined eye contact or verbal initiation as dependent variables. The relation between exercise and mood is also understudied, although studies with nonautistic populations generally support the claim that exercise improves mood (Dodson & Mullens, 1969; Folkins & Sime, 1981; McCann & Holmes, 1984).

Current Study

Given these gaps in the autism literature, the specific effects of exercise on the core autism symptoms remain unclear. Thus, the aim of the current study was to examine the relations between moderate physical activity and self-stimulatory behavior, eye contact, verbal initiation, and overall mood in a boy with autism. Although some psychologists have criticized single-subject designs, a recent article provided justification for the use of case-based research in specific research settings (Borckardt et al., 2008). Case-based designs that track a single participant across baseline and intervention phases provide therapists a means of systematically evaluating the efficacy of their treatment while working with individual patients. To contribute to this efficacy literature, the current case study addressed the following four hypotheses:

1. An exercise program will reduce the frequency of self-stimulation, as seen in past autism studies (Celiberti et al., 1997; Elliott et al., 1994; Gordon et al., 1987; Kern et al., 1984; Kern et al., 1982; Levinson & Reid, 1993; Lochbaum & Crews, 1995; Rosenthal-Malek & Mitchell, 1997; Watters & Watters, 1980).

2. The exercise program will increase the frequency of eye contact. Although past exercise and autism studies have not specifically mentioned this variable, they have reported increased levels of engagement, social play, and appropriate responding after exercise (Kern et al., 1982; Powers et al., 1992). Based on their social nature, these behaviors may include increased eye contact as an underlying dimension (i.e., a child who is engaged by a conversation maintains eye contact with the person speaking).

3. The exercise program will increase the frequency of verbal initiation by decreasing the interference of self-stimulation. Self-stimulatory behaviors can be a significant distraction for children with autism, limiting the variety of actions or number of objects about which they may communicate (Voder & McDuffie, 2006). If exercise reduces the frequency of self-stimulation, the person would have more attention available to coordinate between other people and objects, which may lead to more verbal communication (Charman, 2003). Another line of evidence that supports the relation between verbal initiation and exercise comes from the OT literature. Several studies have reported increased language use and social interaction in children with autism after OT (Case-Smith & Bryan, 1999; McClure & Holtz-Yotz, 1991; Sams et al., 2006). Moderate physical activity shares certain sensory features with an OT session, such as joint pressure and gross motor movement. These commonalities may result in similar improvements in verbal initiation after exercise.

4. The exercise program will improve mood. Although this specific relation has not been empirically demonstrated in the autism literature, studies with nonautistic populations have consistently reported an improvement in mood after physical activity (Dodson & Mullens, 1969; Folkins & Sime, 1981; McCann & Holmes, 1984). Furthermore, researchers examining therapeutic horseback riding for children with autism have found they exhibit happier moods after these sessions, and riding shares certain parallels with exercise (All et al., 1999; Bizub et al., 2003; Martin & Farnum, 2002). For example, a horse's movements mirror those of a human gait, and riders describe the sessions as "strenuous without being overtaxing" (Bizub et al., p. 382).

Method

Participant

The participant was a 12-year-old boy with autism, diagnosed by the Childhood Autism Rating Scale (CARS; Schopler, Reichler, DeVellis, & Daly, 1980) at the age of 32 months. His CARS score of 34.5 placed him in the *Mildly-Moderately Autistic* range. He received scores indicative of more severe difficulties in the areas of *relating to people*, *emotional response*, *visual response*, *fear or nervousness*, and *verbal communication*.

During the current study, the participant lived at home and attended a special education class in a public middle school. After school and on the weekends, he received one-on-one ABA therapy (25 hr/week on average). His wide variety of instructional programs included expressive labels, sight words, verbal imitation, writing, self-help skills, recreation, sequencing, and mathematics. The first author became one of his ABA therapists 17 months prior to data collection, working with him an average of 10 hrs/week. She received training and monthly supervision from a certified ABA consultant.

Once a week, the participant attended a 45-min OT session. His occupational therapist spent 15 min on activities to improve functional performance; 15 min on exercises to develop strength, endurance, and range of motion; and 15 min on neuromuscular reeducation of movement, balance, coordination, kinesthetic sense, posture, and proprioception.

The participant also attended a weekly 50-min therapeutic horseback riding session. The instructor incorporated exercises targeted at balance, coordination, and motor skills (e.g., throwing a bean bag into a hula-hoop on the ground). Each session included one or two additional children with autism.

The participant's daily pharmacological treatment included the antidepressant fluoxetine (Prozac®) through Day 5 of the study and the atypical antipsychotic ziprasidone (Geodon®) through Day 9. His physician prescribed Prozac to treat anxiety and Geodon to treat aggressive behavior. His Prozac prescription changed to fluvoxamine (Luvox®) on Day 6. On Day 10, his medication regimen was switched completely due to undesired weight gain to include the following prescriptions: the atypical antipsychotic quetiapine (Seroquel®), the anxiolytic clonazepam (Klonopin®), and the antihypertensive medication guanfacine (Tenex®).

The child passed his annual physical exam 7 months prior to data collection, with the physician's approval of an exercise intervention. His parent gave consent for his participation in the study.

Intervention

Although we intended to implement a 15-min running intervention, the participant refused to remain on the treadmill for the entire length of time. Instead, he ran for 5 min 45% of the days and 8 min 55% of the days. The treadmill, located in the participant's home, moved at 4.5 mph, a pace chosen to be mildly strenuous (e.g., increased breathing rate or slightly flushed face) but not painful (e.g., shortness of breath or cramped muscles). The appropriate intensity level has been shown to be critical for reducing stereotypic behaviors (Celiberti et al., 1997; Elliott et al., 1994; Kern et al., 1984; Levinson & Reid, 1993). During each exercise session, the experimenter verbally reinforced the participant (e.g., saying "Good job") on average once per minute for running. The exercise intervention occurred two afternoons per week.

Dependent Measures

Frequency of self-stimulation. Wing's (1972) definition of self-stimulatory behavior, that is, repetitive body movements or repetitive movement of objects, served as an adequate definition because the participant's familiar tutor could easily identify his specific stereotypic behaviors. Particularly common examples included hand-flapping, scratching, sniffing people or objects, twirling a plastic straw, rocking from front to back or from side to side, and jumping. In the current study, one continuous movement counted as one incident of self-stimulation. For example, the participant's rocking back and forth counted as one incident if the movement was not divided by a rest interval of 1 s or more.

Frequency of eye contact. We defined eye contact as meeting and holding the gaze of another person for at least 2 s duration. Each continuous gaze counted as one incident of eye contact, separated from the next incident by the participant looking away.

Frequency of verbal initiations. Speaking at least one word, unprompted and in an audible voice, defined verbal initiation. One word or one continuous sentence counted as one incident. Any period of silence longer than 1 s after the onset of verbal initiation marked the offset.

Negative and positive mood frequency. The Aberrant Behavior Checklist (ABC), a rating instrument for assessing maladaptive behavior of individuals with developmental disabilities (Aman, Singh, Stewart, & Field, 1985), served as the basis for the operational definitions for negative and positive mood. The following items from the Irritability and Lethargy subscales indicated negative mood: screaming inappropriately, throwing a temper tantrum, acting irritable or depressed, crying over minor annoyances or hurts, stamping feet, resisting any form of physical contact, and responding negatively to affection. Other indicators of negative mood included throwing himself on the floor and refusing to obey requests. Although the ABC does not specify adaptive behaviors, the opposites of the previous negative items provided clear indicators of positive mood: smiling, laughing, singing, skipping, requesting physical contact, responding positively to affection, and obeying requests. Any period of absence of these behaviors after their onset indicated their offset.

Design and Procedure

The current study employed a single-subject design. Unlike traditional designs comparing experimental to control groups, the single-subject design involves a comparison between time periods for the same participant (Bloom, Fischer, & Orme, 2006). These time periods include both a nonintervention or preintervention phase and an intervention or postintervention phase. Specifically, the current study employed the repeated preintervention-postintervention design, in which we measured the participant's targeted behaviors immediately before and immediately after each exercise session (Thyer & Curtis, 1983). The preintervention data allow the single-subject design to use the participant as his own control (Bloom et al., 2006).

Thyer and Curtis (1983) asserted that their design reduces threats to internal validity because only the duration of the intervention separates the pre and post measures, decreasing the possibility of extraneous factors influencing the dependent variable. Thus, the preintervention-postintervention design is logically more powerful than the basic *A-B* design, which simply combines a baseline observation period (*A*) and an intervention period (*B*). Indeed, Thyer and Curtis's design has been praised as "one of the most useful designs" for single-subject research, given its dual benefits of increased internal validity and practical applicability (Stanley, 1985, p. 33). The preintervention-postintervention design is especially useful for treatments where participants may show an effect immediately following a therapy session, such as an exercise intervention.

The current study, which gained approval from the Human Subjects Institutional Review Board, lasted from January 14, 2008 until March 14, 2008. The first author collected frequency data on the participant's self-stimulation, eye contact, verbal initiation, and mood before and after the running condition. A Fujitsu Lifebook Tablet™ computer, with the BASC-2 Portable Observation Program™ software (Version 2.0; 2006), kept track of observed frequencies of pre- and postintervention data. The data collection protocol called for recordings two afternoons per week, beginning the behavioral observation directly after the participant returned home from school when he normally experienced his ABA therapy. However, he did not attend a full day of school on Days 2, 3, 9, 10, 11, 13, 14, 17, and 18 due to snow cancellations (2 days), behavioral problems (3 days), or medical appointments (4 days). On those days, data collection still occurred during his normal ABA therapy, immediately before and after the exercise intervention. All observation periods in the study were 30 min, divided into 10-min time blocks to allow a more detailed assessment of his behavioral variability on any given day. The one exception involved the self-stimulation variable. Because of the participant's relatively high frequency of self-stimulation, we used six 5-min time blocks during the pre- and postexercise observation periods for this behavior.

Data Analysis

To analyze the data, we used the SINGWIN™ (2006) program, "the most comprehensive program for the analysis of single-system design data" (Bloom et al., 2006, p. 530). With a single-subject design, inferential statistics are not appropriate for data analysis because these measures are built on the variability of a sampling distribution, and the current sample included only one participant.

To determine the statistical significance of changes in the outcome variables, we used the conservative dual-criteria (CDC) approach (Bloom et al., 2006). Using preintervention data, one computes a mean and a regression line and then adjusts both of these lines by .25 of the standard deviation of the preintervention data. This product is added to each line, which gives the CDC approach its conservative nature. The adjusted lines are plotted with the postintervention data to show significant changes in behaviors. For a positive behavior (e.g., eye contact), all observed frequencies that fall above both adjusted lines count as successes. For an undesirable behavior (e.g., self-stimulation), all observed frequencies that fall below both adjusted lines count as successes. One compares the total number of successes to the number of observations expected to satisfy both criteria by chance alone, using the binomial equation.

The versatile CDC test is especially useful for a single-subject design because it maintains accuracy even with autocorrelated data. According to Borckardt et al. (2008), autocorrelation (i.e., the value of one observation depending on the value of one or more of the prior observations) is an issue often cited by critics of the case-based approach. This lack of independence between observations violates important assumptions behind conventional statistics, so the CDC method controls for autocorrelated data through conservative adjustments. In the current study, the SINGWIN program computed the CDC approach, with alpha levels set at .05. In addition to testing differences between preintervention and postintervention data, this approach analyzed the consistency of target behaviors and the temporal effects of exercise across the time blocks.

Results

Figure 1 presents the participant's self-stimulation frequency pre- and postexercise, with each data point averaged over 6 consecutive intervention days. The "intervals" along the *x*-axis represent each 5-min time block during the 30-min observational periods. The CDC analyses revealed a statistically significant postexercise reduction in self-stimulation across all days (see Table 1). Table 1 also shows that the exercise intervention failed to produce significant improvements in eye contact, verbal initiation, negative mood, and positive mood. In fact, the participant exhibited significantly fewer positive mood behaviors after exercise on 12 of the 18 intervention days. No consistent patterns in

TABLE 1

Total Number of Postexercise Observation Intervals Below or Above Both Criteria[a] *and the Total Number Needed for Significance for Each Variable*

Days	1 to 3	4 to 6	7 to 9	10 to 12	13 to 15	16 to 18
Self-stimulation, *N(b)* = 18						
N(b)) below both	18*	17*	16*	17*	18*	18*
Needed below both	13	13	13	13	13	13
Eye contact, *N(b)* = 9						
N(b) above both	4	0	4	0	2	4
Needed above both	8	8	8	8	8	8
Verbal initiation, *N(b)* = 9						
N(b) above both	4	2	3	2	1	4
Needed above both	8	8	8	8	8	8
Negative mood, *N(b)* = 9						
N(b) below both	7	0	6	2	5	6
Needed below both	8	8	8	8	8	8
Positive mood, *N(b)* = 9						
N(b) above both	0	1	2	1	0	0
Needed above both	8	8	8	8	8	8
N(b) below both	9*	8*	7	7	9*	9*
Needed below both	8	8	8	8	8	8

Note. *N(b)* = the total number of postexercise observation intervals. Self-stimulation data were collected in six 5-min blocks; other variables were collected in three 10-min blocks.

[a]The two criteria were the adjusted mean and regression lines, as computed by the conservative dual-criteria approach.

*$p < .05$.

observed frequencies appeared between the postexercise time blocks for any variable.

Discussion

The participant's significant postexercise reduction in self-stimulation clearly supports the study's first hypothesis and replicates past autism research (Celiberti et al., 1997; Elliott et al., 1994; Gordon et al., 1987; Kern et al., 1984; Kern et al., 1982; Levinson & Reid, 1993; Lochbaum & Crews, 1995; Rosenthal-Malek & Mitchell, 1997; Watters & Watters, 1980). One noteworthy difference between the current study and previous studies concerns the duration of the exercise intervention. The participant remained on the treadmill for a relatively brief period of 5 to 8 min, compared to the typical 15- to 20-min exercise sessions in past studies. Although he ran for considerably less time, the participant still experienced a significant decrease in self-stimulatory behaviors, suggesting that exercise can be an easy and efficient intervention for children with autism. The reduction of self-stimulation is important because these stereotypic behaviors often interfere with positive social behaviors and learning in the classroom, making the integration of children with autism into mainstream schooling more difficult (Rosenthal-Malek & Mitchell, 1997). In addition to being an inexpensive and relatively simple method to decrease self-stimulation, an exercise intervention can provide a complementary treatment option to traditional contingent behavior management. By identifying antecedent conditions (e.g., physical activity level) that alter problem behaviors (e.g., self-stimulation), parents and teachers of children with autism can prevent undesirable behaviors before they even happen, instead of treating them with aversive stimuli after each occurrence (Elliott et al., 1994).

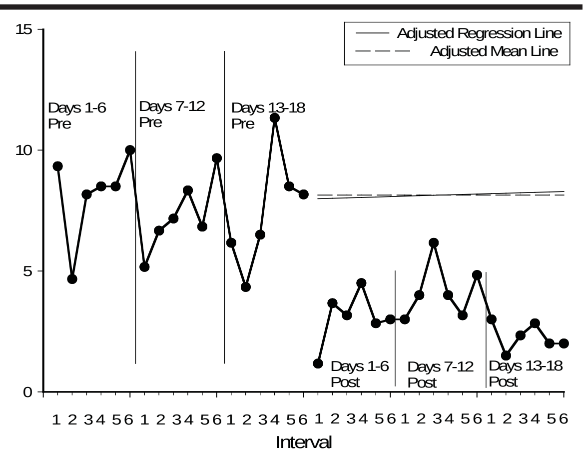
The current study found that self-stimulation decreased after as little as 5 min of mildly strenuous physical activity. Future research should further investigate the differential effects of various exercise durations on stereotypic behaviors for individual children. What amount of time is optimal for the greatest reduction in an individual's self-stimulation? A similar question involves the durability of the behavioral improvement. Although the current participant maintained a relatively low frequency of self-stimulation across the postexercise time blocks, other researchers have reported a gradual increase in self-stimulation after the first 10-min observation period (e.g., Celiberti et al., 1997). Understanding the duration of exercise effects carries practical significance for parents and teachers, as they can incorporate multiple exercise sessions into their children's daily routines to consistently decrease problematic self-stimulation.

Our results did not support the hypotheses that exercise would increase eye contact and verbal initiation. One explanation for the failure to find significant improvements involves this participant's overall low frequencies of these two behaviors. He often exhibited zero occurrences of eye contact and verbal initiation during an observational time block or even across an entire session. The CDC approach requires a minimum of five nonzero data points during an observation to detect a statistically significant change (Bloom et al., 2006). Future research should examine the effects of exercise on eye contact and verbal initiation using a broader sample of children with autism, including those who naturally exhibit a higher baseline rate of prosocial behaviors, which may be necessary for exercise to cause an improvement.

An intriguing new area of autism research may provide a link between exercise and improved social communication if exercise raises core body temperature. Recent reports from parents and clinicians suggest that certain behaviors of children with autism tend to improve during periods of fever. Curran et al. (2007) conducted a prospective study to examine this fever effect beyond case reports and anecdotes. Their sample included 60 children (aged 2-18 years) with autism spectrum disorders. Half experienced fever episodes, defined as a body temperature of greater than 38.0°C. The other half were afebrile, matched on age, gender, and language skills. Parents of the febrile children responded to the ABC (Aman et al., 1985) at three times: the first day of the child's fever, one day after the fever disappeared, and one week after no fever symptoms. Parents of the afebrile children responded to the ABC at similar time intervals. Significantly fewer aberrant behaviors were recorded for the febrile children compared to the afebrile children. Improved communication was the most notable behavioral change, and this improvement did not depend on the height of fever. If the important biological mechanism for reducing autism symptoms is raising body temperature, perhaps exercise can produce similar therapeutic effects. The current participant tended to sweat heavily after 5 min on the treadmill, so future research might include recording body temperature and looking for communication improvements in children with higher baseline rates of eye contact and verbal initiation.

FIGURE 1

Self-stimulation frequency pre- and postexercise averaged over 6 consecutive intervention days.



The participant's mood results produced a surprising finding. Contrary to the hypothesis that exercise would improve mood, his frequency of negative mood behaviors did not significantly change. Furthermore, his frequency of positive mood behaviors significantly decreased after exercise on 67% of the days. For this particular boy, the experience of running on the treadmill did not appear to be enjoyable. Although previous studies have reported children with autism jogging or running for 20 min at a time (e.g., Kern et al., 1982), the current participant threw tantrums and refused to run beyond 8 min. This unexpected finding serves as a reminder that not all children or adolescents will comply with a given intervention, and parents and teachers should rely on effective methods that can be easily incorporated into daily routines. One methodological difference is the current study's treadmill use, compared to the exercise conditions in other studies where participants ran around a gymnasium or an outdoor grass field. The treadmill presents fewer sensory distractions (e.g., trees, cloud, additional children) and more physical limitations (e.g., necessity to run in a straight line) than a gymnasium or field. These differences may partially explain the unexpected findings related to mood.

A second potential explanation involves the relation between self-stimulation and positive mood behaviors. Previous studies (e.g., Martin & Farnum, 2002) have suggested a link between happy mood and certain stereotypic behaviors such as hand-flapping, which may be an expression of excitement for children with autism. If so, a significant postexercise reduction in self-stimulation might also decrease the frequency of positive mood behaviors. Indeed, the current participant exhibited a moderate correlation between his baseline frequencies of self-stimulation and positive mood, $r(54) = .67$. The close relation between these two behaviors may explain why positive mood frequency decreased along with self-stimulation after exercise.

The current study contained several limitations. An inherent concern for any single-subject design involves external validity. How generalizable are the current participant's results to a larger population of children with autism? His postexercise reduction in self-stimulation replicated previous findings from studies with a wider variety of participants. This consistency of effects strengthens the authors' contention that exercise decreases self-stimulatory behaviors in this population. The eye contact, verbal initiation, and mood results, however, may be less applicable to other children with autism. A key point is that autism is a spectrum disorder; children are differentially affected, each experiencing difficulties along a continuum (Bauman & Kemper, 2006). This wide range of problem behaviors and symptom severity limits researchers' ability to generalize about the effects of an exercise intervention.

An additional methodological concern involved threats to internal validity. Due to unforeseen and uncontrollable circumstances (e.g., medication changes, school cancellations, participant behavioral problems), the treatment could not be implemented in the originally intended way with a consistent medication regimen, a regular school routine, and a 15-min running condition. The study was further limited to 9 weeks of pre- and postexercise data collection. An improved design would track the participant over a longer period, granting enough time for the behaviors to stabilize and providing more observational data for a representative average. Future research should also rely on multiple observers to record the participant's targeted behaviors. This methodological improvement would provide a measure of interrater reliability and minimize the threat of experimenter bias.

Although the current single-subject design study contained limitations related to external and internal validity, it produced an in-depth analysis of the effects of exercise on a child with autism. A primary advantage of this approach was the ability to observe and record five variables simultaneously. Future autism research should maintain this focus on multiple behaviors, given the complex spectrum nature of the disorder. The exact effects of physical activity on the core symptoms of autism appear to depend on multiple factors, including the exercise duration, the exercise setting, and the characteristics of the child. The relative importance of these individual factors remains unknown, thus highlighting the need for further exploration and future experiments in the area of exercise and autism.

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