The Effects of Exercise Dose on Stereotypical Behavior in Children with Autism

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ABSTRACT

SCHMITZ OLIN, S., B. A. MCFADDEN, D. L. GOLEM, J. K. PELLEGRINO, A. J. WALKER, D. J. SANDERS, and S. M. ARENT. The Effects of Exercise Dose on Stereotypical Behavior in Children with Autism. *Med. Sci. Sports Exerc.*, Vol. 49, No. 5, pp. 983–990, 2017. **Introduction**: Autism spectrum disorder (ASD) is a prevalent neurological disorder in children characterized by restrictive, repetitive patterns of behavior that place an added burden on everyday functions. Aerobic exercise has the propensity to reduce stereotypic behaviors in children with ASD. This study sought to quantify the acute effect of exercise and to assess the influence of duration and intensity on the frequency of stereotypic behaviors in children with ASD. **Methods**: Participants in this study (N = 7, M_{age} = 13.0 ± 1.4 yr, M_{height} = 1.64 ± 0.01 m, and M_{weight} = 60.1 ± 13.7 kg) underwent five separate days of treatments, including a control condition (C), a low-intensity 10-min condition (10L), a high-intensity 10-min condition (10H), a low-intensity 20-min condition (20L), and a high-intensity 20-min condition (20H) in which intensity was quantified using HR as well as RPE. Before and 60 min after exercise, the frequency of stereotypic behaviors was recorded. **Results**: Results indicated a reduction in behaviors in response to exercise compared with the C trial throughout all conditions except 20H. Interestingly, the most exhaustive exercise session led to increased stereotypic behaviors at all postexercise periods compared with the other exercise trials (P < 0.10). The 10L condition showed the greatest reduction at 60 min postexercise compared with the 20H or the control trial's response (P < 0.05). Examining the behavioral responses to exercise using effect sizes indicated the 10L condition showed the greatest reduction in frequency throughout all four time points (ES_{range} = −0.87 to −1.03) compared with baseline. **Conclusion**: Although it appears high-intensity aerobic exercise may exacerbate stereotypic behaviors in children with ASD, low- to moderate-intensity exercise produces significant and large reductions in these behaviors. This provides an easily administered and cost-effective way to positively impact these individuals. **Key Words:** SELF-STIMULATORY BEHAVIORS, OMNI SCALE, HEART RATE, AEROBIC EXERCISE, ASD

Autism, along with Asperger syndrome, Rett syndrome, childhood disintegrative disorder, and pervasive developmental disorder—not otherwise specified, falls under the umbrella diagnosis of autism spectrum disorder (ASD). The definition of ASD according to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*, can be summarized as a neurodevelopmental disorder characterized by impairments in social interaction and communication not accounted for by general developmental delays and accompanied by restricted, repetitive patterns of behavior that limit and impair everyday functioning (3). ASD has a recognized prevalence of 1 in every 68 children born in the United States, and that number is growing annually (11). Filipek et al. (15) contend that ASD is the prevailing neurological disorder among children, with a reportedly higher incidence than cancer, diabetes, Down syndrome, or spina bifida within the pediatric population.

ASD is typically diagnosed early in childhood with approximately 43% of children recognized by age 3 yr (11). Therefore, the focus of a large majority of the research in this area has been on children. Repetitive and restrictive behaviors, otherwise known as stereotypical or self-stimulatory behaviors (SSB), are commonly seen in individuals with ASD. These may include inflexible routines as well as repetitive speech and habitual motor movements such as hand flapping, rocking the body, or spinning in circles (24,32). These behaviors have been noted for their propensity to cause sensory stimulation. The social behaviors exhibited by these children are not only detrimental to the individual but may also effectively disrupt the learning environment for their peers. These behaviors range in severity and frequency, the latter offering itself to objective quantification, with the former mandating some form of subjectivity by the observer. Currently, there is no medical cure for ASD

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nor are behavioral medications typically observed to improve behavior without additional interventions (5,22) Lack of effective treatment methods presents a need to reduce stereotypical behaviors without undesirable side effects from drug or aversive therapies.

Operant conditioning, social skills training, and integration are commonly used methods of addressing the behavioral miscues associated with ASD. Research on therapeutic interventions such as the use of social disapproval (10), overcorrection (10,21,25,39), time out (10,39), sensory extinction (10,20), reinforcement of incompatible behavior (10,39), and physical restraint or punishment (21,39) has generally found these methods to be nonefficacious for addressing maladaptive patterns of behavior associated with disorder. Furthermore, many of these commonly used techniques are largely "negative" in their approach to quelling the stereotypical behaviors. This inadequacy of options leaves a void in effective treatment possibilities available to parents/practitioners. Fortunately, one potential intervention that has a much more "positive" connotation has received some preliminary support for its efficacy in reducing SSB associated with ASD.

Aerobic exercise has been shown to reduce SSB (6,10,20,21,25,34,39) in children with ASD. Exercise is a desirable treatment to reduce SSB for a multitude of reasons. Not only is it inexpensive and easy to administer, but the added health benefits of exercise may help improve quality of living in children with autism. In a review of the literature, Petrus et al. (30) concluded that of the seven studies included for analysis, each found that the beneficial effects of exercise for reducing SSB were greater when more vigorous aerobic activity was used. Rosenthal-Malek and Mitchell (34) also found that after "mildly strenuous" jogging for 20 min, five children with ASD reduced SSB in the classroom without decreasing academic performance. In fact, responses to academic work increased after the exercise session. A possible explanation given for the exercise-induced reductions seen in these investigations is a "fatigue factor," wherein greater fatigue leads to greater reductions in SSB. However, after a fairly low-intensity exercise, Rosenthal-Malek and Mitchell (34) observed a reduction in SSB as well as an increase in academic performance not generally associated with fatigue.

Despite the findings of previous studies involving exercise and autism, many of the past studies contain at least one or more inherent methodological flaw preventing translation and/or quantification of results. Briefly, some of these shortcomings include inadequate sample size, absence of a control condition, lack of accounting for exercise intensity, and use of nonhomogeneous samples; that is, individuals with ASD being grouped with other mental/cognitive disorders (9,24,30,37). The present study addresses the common methodological faults of previous studies by using a relatively greater number of only ASD participants, applying well-defined exercise standards in accordance with the American College of Sports Medicine (ACSM) guidelines and consistently quantifying exercise duration and intensity using continuous HR monitoring and a rating of perceived exertion (33,38). The constant monitoring allowed intensity/duration to be controlled and quantified for the exercise sessions. The purpose of this study was to quantify the acute effect of exercise and assess the influence of duration and intensity on the frequency of stereotypic behaviors in children with ASD.

METHODS

Participants. Children with autism ($N = 7$, $M_{age} = 13.0 \pm 1.43$ yr, $M_{height} = 1.64 \pm 0.01$ m, and $M_{weight} = 60.1 \pm 13.7$ kg) were selected for participation. This younger age-group was desirable because SSB tend to decrease with age; therefore, it was expected that this population would exhibit higher levels of SSB, thus making it more feasible to detect changes due to treatment. Participants were selected for this study if they exhibited observable forms of self-stimulation and other inappropriate behaviors. As these behaviors are different from person to person, each subject's particular mannerisms were determined and used for the subsequent measure. The primary SSB identified were hand flapping and echolalia. An eighth subject was originally recruited for participation, but his baseline SSB for a whole body tick were more than 3 SD greater than the mean, and he was considered an outlier and removed from consideration. All participants were enrolled in a developmental program in a specialized facility for persons with autism. This study was approved by the Institutional Review Board of Rutgers University, and parental consent and child assent were obtained before participation for all individuals.

Design. All preexercise baseline behavior measurements and postexercise measurements were taken in a typical classroom setting familiar to the subjects. The primary experimenter spent time with the participants before initiation of the study to allow them to become accustomed to the presence of another person in the classroom. To record the children's behaviors before and after exercise, a video camera was set up in the room in such a manner that it did not distract the participants. After a 15-min precondition observation period, the participants were escorted to the gym where they performed the experimental conditions, which were substituted for regular physical activity sessions within the same gym used for class, two to three times per week, until all five sessions were completed. Sessions were conducted at the same time of day, and the classroom activities before and after each session were similar in that they primarily consisted of the teacher talking and the students required to sit in their chairs and listen/participate. Participants were randomly assigned to the order in which these sessions occurred. The control session (C) involved a no-exercise treatment within the confines of the gymnasium. During their first exercise condition, participants self-selected a cycling, treadmill, or elliptical ergometer. This same mode was repeated for all subsequent sessions. A total of four subjects selected the treadmill, and the other three all chose the stationary bike.

Continuous aerobic exercise was performed at a low (L) or high (H) intensity for either 10 or 20 min. Four specified exercise sessions served as experimental conditions: 10L, 10H, 20L, and 20H. Quantification of exercise intensity was determined by use of a Polar HR monitor: L between 50% and 65% age-calculated maximal HR (HR_{max}) and H between 70% and 85% HR_{max} via continuous measurement, along with assessment of a rating of perceived exertion every 3–5 min using the OMNI scale (33,38). The OMNI scale was chosen because it provides a pictorial representation of a rating of perceived exertion scale and does not force participants to assign a number to how tired they feel. Because of the communicative barriers associated with autism, the OMNI scale was ideal for use with this group of subjects. Subjects were asked every 3–5 min during exercise how they were feeling and were instructed to point to a person on the diagram who best represented how hard they were working. OMNI ratings of 3–5 were used for the L conditions and 6–8 for the H conditions. Subjects established a self-selected "preferred" pace initially, and then HR and RPE were brought into the target ranges through a combination of modest verbal cues to modify speed and manipulation of grade/resistance by the experimenter. Because of the close monitoring, subjects did not deviate from the targeted ranges. After the exercise session was completed, participants performed a brief cooldown then returned to the classroom and were again observed via video camera. Postexercise measurements lasted 1 h to account for the duration of effects of exercise on stereotypic behaviors.

SSB assessment. Video recordings were scored for the frequency of SSB in 15-min blocks for the 15 min leading up to the session (preexercise, used as baseline) and postexercise (0–15, 15–30, 30–45, and 45–60 min). The initial presession block served as a baseline for each condition. The same individual tallied the SSB for all sessions. This person was blind as to which treatment they were scoring. A second blinded individual scored each session, and the primary observer rescored two 15-min samples from each session so that inter- and intraobserver reliability could be calculated. Intraobserver reliability was calculated to be 0.92, and interobserver reliability was 0.94; thus, all scoring was considered reliable.

Analysis. Data were analyzed using a repeated-measures 5 × 5 (condition × time) ANOVA, and interaction effects followed-up by examining simple effects of condition within time. For each of the univariate analyses, examination of the Huynh–Feldt epsilon for the general model was used to test the assumption of sphericity. If this statistic was larger than 0.75, sphericity was considered to have been met and the unadjusted univariate statistic was used. When epsilon was less than 0.75, it was considered a violation of the assumption of sphericity and the Huynh–Feldt (H-F) adjusted statistic was used to test significance. Pairwise comparisons were then used to determine significant differences in behaviors for each condition at each time point by examination of the 95% confidence interval. Because of the difficulty in obtaining a large participant number within this population combined with the exploratory nature of this study and potentially large impact results could have on the autistic population, alpha was set at $P < 0.1$. To determine the magnitude of these differences, effect sizes (ES) were calculated using Hedges g, with a positive value signifying an increase in SSB and a negative value a decrease. All data were analyzed with SPSS software v21.

RESULTS

A significant condition main effect ($P < 0.01$) as well as a significant time–condition interaction effect ($P < 0.10$) were found. Univariate analysis revealed no differences across all conditions in SSB_{pre} ($P > 0.45$). There were significant differences between conditions in the first 15 min after exercise ($P < 0.05$). Pairwise comparisons indicated that 20H produced significantly worse SSB than all other conditions ($P < 0.10$) except C ($P > 0.10$). There were also significant differences between conditions at $post_{30}$ ($P < 0.05$), with 10L producing significantly greater reductions in SSB than either 20L or 20H ($P < 0.10$). C differed only from 20H ($P < 0.10$). Significant differences between conditions at $post_{45}$ ($P < 0.08$) appeared to be due to the fact that 10L produced significantly greater reductions in SSB compared with all other conditions ($P < 0.10$). Differences between conditions also emerged at $post_{60}$ ($P < 0.01$), with 10L producing better effects on SSB than C or 20H ($P < 0.05$), and SSB for 20H were significantly worse than all conditions ($P < 0.10$) except the C.

The pattern of response differed between conditions as well. The 10L condition resulted in continually lower SSB frequency through the 60 min. Both the 10H and the 20L conditions saw an initial drop in SSB within the first 15 min, a return toward baseline at $post_{30}$, and another decline during the final 30 min. The 20H treatment increased SSB occurrence within the initial $post_{15}$, and this remained elevated despite some undulation throughout the observation period (see Fig. 1).

Examining the magnitude of these responses through ES demonstrated several important findings. First, during C, there were no differences from baseline through $post_{45}$, but this was followed by a large increase in SSB at $post_{60}$ as compared with baseline (ES = 0.81). Second, the 10L condition generated the largest and most consistent reduction in SSB frequency from baseline. A moderate decrease (ES = −0.54) was observed at $post_{15}$, with large decreases at $post_{30}$, $post_{45}$, and $post_{60}$ (ES = −0.87, −1.12, and −1.03, respectively). The 20L session produced a small decrease in SSB at $post_{15}$ and $post_{60}$ (ES = −0.36 and −0.23, respectively) and trivial effects at $post_{30}$ and $post_{45}$ (ES = +0.15 and −0.06, respectively). After the 10H treatment, a moderate reduction in SSB was once more observed during the initial 15 min after exercise (ES = −0.55), although

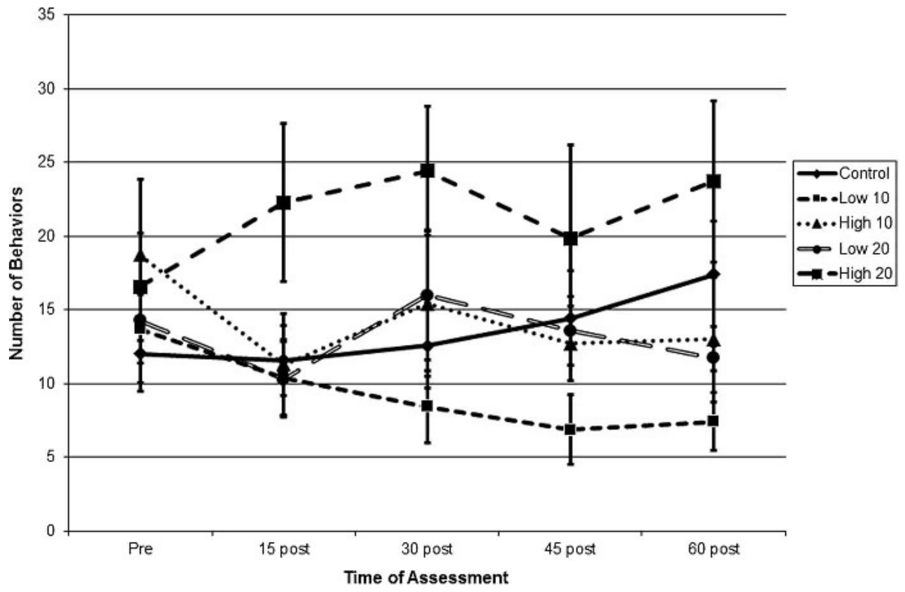

FIGURE 1—Time course of SSB pre- to postintervention. Figure 1 shows the number of SSB of each condition (control, 10L, 10H, 20L, and 20H) assessed from preexercise to 60 min postexercise intervention.

only small ES followed (ES = −0.24, −0.44, and −0.42, sequentially). Again, a notable result was that the 20H treatment was the sole exercise condition that led to an increase in SSB from pre- to postexercise, with a moderate increase observed at $post_{15}$ (ES = 0.59) and large increases at $post_{30}$ and $post_{60}$ (ES = 0.82 and 0.74, respectively) (see Fig. 2).

DISCUSSION

Overall, the observation was a reduction in SSB in response to exercise, particularly of a shorter duration and lower intensity when compared with either baseline values or a control trials' response. When comparing durations of 10 and 20 min and intensities of 50%–65% HR_{max} to 70%–85% HR_{max}, it was observed that shorter and less intense exercise bouts were more effective in reducing SSB in children with ASD. The 10L session yielded the greatest reduction of all conditions at every time point postexercise, with the largest difference from the control occurring in the latter part of the 60-min postexercise observation period. Moreover, the most exhaustive exercise session (longest duration and highest intensity) actually led to an increase in SSB frequency from baseline. The 20H condition was the

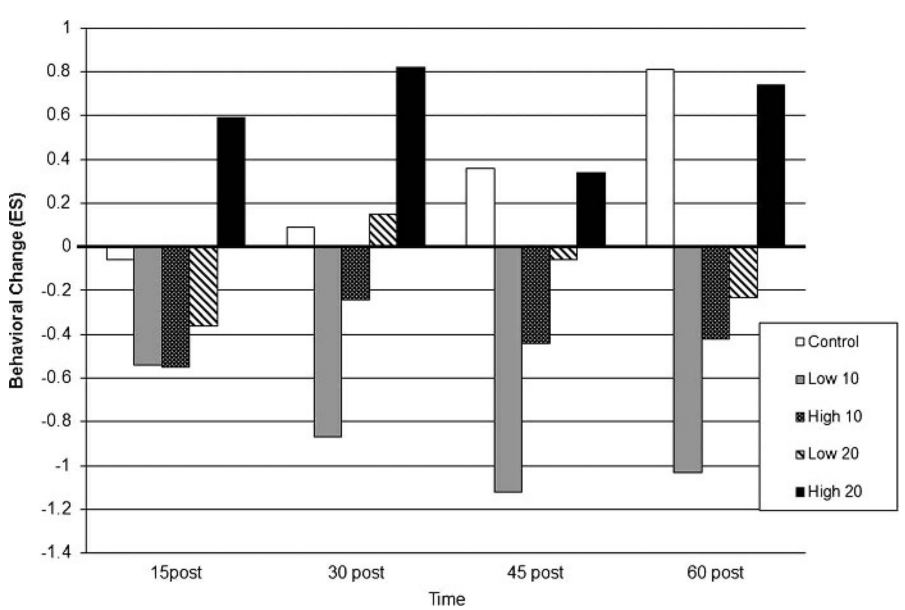

FIGURE 2—SSB change ES. SSB behavioral change ES for control, 10L, 10H, 20L, and 20H conditions for 15–60 min postexercise intervention.

only treatment that increased SSB from the preexercise level and failed to be more effective than the nonexercise control. This suggests a negatively sloped dose–response to exercise for children with ASD.

Previous research has shown the effectiveness of reducing stereotypic behaviors by exercise bouts of varying duration, from 3 to 45 min (8,18), with positive results lasting up to 90 min postexercise (20). Celiberti et al. (10) noted that in one 5-yr-old autistic male, there were sharp reductions (31%) in behaviors after a 6-min jogging session, but not from walking the same duration. Gordon et al. (18) observed that a mere 3-min bout of running was also able to reduce stereotypic behaviors in one autistic boy. In this case, exercise was used in response to a behavior; it is noted that the use of contingent exercise allows for the possibility of embarrassment for the child and, thus, reduced effectiveness over time. Also, being limited to only one participant, the interpretation of these observations for application to a larger population would be difficult. Furthermore, these studies both failed to accurately assess exercise intensity beyond the verbal description of jog/walk/run.

Several studies have attempted to quantify or control exercise intensity. One investigation compared 15-min sessions of walking versus jogging (25). Pre- and post-HR values were recorded but were taken by radial pulse and not assessed during the exercise bout. Although the walking trial did not reduce stereotypic behaviors, jogging resulted in a 17.5% reduction in such behaviors. While lack of precise or accurate assessment of intensity precludes direct comparison, these findings are generally inverse to those of the current study. Elliott et al. (14) went a step farther, comparing three levels of activity, a nonexercise control, a general motor training session (HR = 90–120 bpm), and vigorous aerobic exercise (HR > 130 bpm). In contrast to the current study, the only significant reduction in stereotypic behaviors was seen with the vigorous exercise condition. These discrepancies can be explained, in part, because of the present, more meaningful categorization of HR ranges (with the current values being based on ACSM health and fitness recommendations) and in part from a more accurate assessment of HR (continuous monitoring during activity with a polar HR monitor here as compared with intermittent radial pulse while standing still in the previous studies). Moreover, the Elliott et al. (14) study included six institutionalized adults with autism and mental retardation. Several such investigations reporting on autism/ASD similarly include individuals with compounded or entirely different disorders (1,5,8).

Contrary to the current study, much of the previous research has suggested that vigorous exercise has a more pronounced beneficial effect at reducing stereotyped behaviors than lower intensity exercise protocols (10,14,20,24,25). This may stem from the lack of standardized criteria used to determine intensity in earlier investigations. It is quite possible that "low" intensity from those studies falls below either of our classifications, whereas our low-intensity equates more closely with the "vigorous" intensity used in previous designs, and the high classification is in excess of intensities previously implemented. A more recent study by Oriel et al. (28) failed to find a significant effect of exercise on stereotyped behaviors in children performing a running/jogging protocol for 15 min. The exercise intensity was measured by the use of observing a flushed face and increased breathing rates to determine that the exercise was strenuous. A possible reason for the failure to find an effect may be due to the intensity of the exercise performed. However, without the use of acceptable and quantifiable measures to determine exercise intensity, it is difficult to conclude if the exercise protocol was sufficiently vigorous to be considered high intensity.

Despite methodological shortcomings, early research in this area was invaluable in providing information for future studies to build upon. However, insufficient sample size (i.e., n = 1) (2,10,18), inclusion of non-ASD individuals (1,5,8,14), and/or insufficient measurements of exercise intensity (8,10,14,20,25,28,34) are problematic and make direct comparison of results difficult. The novelty of the current study lies in the relatively larger sample size, the use of an accurate assessment of intensity during the exercise bout, the control over setting (location and time) to eliminate environmental variability, and the systematic manipulation of duration and intensity allowing for a more detailed report on the effects of exercise on stereotypic behaviors in children with ASD.

The practical implications of these findings are extensive, particularly as effective treatment methods devoid of side effects are lacking for this diagnosis. Ten-minute sessions could manageably be included within the regular curriculum with minimal interference of other academic activities. Teachers and aids can implement several short durations of exercise sessions throughout the day to help reduce SSB. In addition, these sessions could cumulatively aid in having the individual meet ACSM guidelines for health and wellness. In fact, a longitudinal investigation examining the efficacy of a 9-month treadmill-walking program on the health status of adolescents with autism supports the use of regular exercise in this regard (31). Pan (29) also observed behavioral improvements in children with ASD in response to water-based exercise in combination with social skills training. In that investigation, a 90-min, twice per week "Water Exercise Swimming Program" intervention was used to develop the social skills of children with ASD during the course of 10 wk. The exercise in our study offers a more generalizable application in a school setting as it is significantly less time consuming, does not require access to a pool, and involves a lower instructor–student ratio. These results also provide important information about an affordable and effective strategy (exercise of proper duration/intensity) in the management of ASD. Furthermore, this population can derive great benefits from a physical activity intervention as research has found that children with ASD are at a higher risk of being overweight or obese than the general population and thus suffer from various diseases of inactivity (13).

Physical activity has also been found to improve academic skills in children with ASD (27). Another outcome of the current study was the relative usefulness and ease of using the OMNI Scale. The heightened tactile response of this population may make use of chest straps and HR monitors necessitating physical contact with the individual very difficult. Fortunately, subjects in the current study were very tolerant of the chest straps, although many "fidgeted" with them for the first minute or two before leaving them alone for the duration. We found the OMNI Scale to be a viable alternative to assessing intensity within the ASD population.

This study supports the use of short, low-moderate intensity (50%–65% HR_{max}) exercise in children and adolescents with ASD as a means of reducing SSB for up to 1 h. However, there appears to be a dose–response relationship associated with exercise workload and reductions in SSB, whereas the greatest reductions in behavior were a result of the lowest workload and the only consistent increase in SSB was a result of the highest workload. This suggests that the more a child exercises beyond a certain threshold of intensity and duration, the less notable the reduction in SSB. High-intensity exercise may increase physiological arousal to the point where the system is overloaded and does not recover sufficiently thus leading to increases in SSB. However, moderate intensities may "balance out" the physiological system resulting in reductions in behaviors due to a state of more optimal stimulation. This is not without precedent in the psychosocial or behavioral response to exercise literature. Previous studies involving exercise and anxiety have shown that anxiety and tension are decreased as a result of exercise at more moderate intensities but are unchanged or increased as a result of high intensities (4,23). As such, decreased tension (or enhanced calmness) may lead to reductions in SSB in this population. More research is required to definitively state such an association.

Given that fatigue may not be the primary mechanism for the efficacy of exercise, another likely explanation for the noted reductions in SSB is that the physical stimulation of exercise is found to be similar to that obtained from performing stereotyped behaviors. SSB are hypothesized to arise because the behavior itself produces a pleasant internal consequence (24,32). Exercise may involve similar feelings driven by body mechanics that resemble the stereotyped behavior (24). Other research suggests an increase in the release of specific neurotransmitters, beta-endorphins, and serotonin seen with exercise may be a causal factor in reducing stereotypic behaviors (7,16,35). Serotonin levels have been implicated in contributing to the SSB in children with autism. Serotonin has an excitatory effect on muscle control and an inhibitory effect on pain and sensory perception (40). Cook et al. (12) found higher serotonin levels in the whole blood of children with autism. The use of serotonin transporter inhibitors was subsequently administered to decrease blood serotonin levels and a decrease in ritualistic behaviors resulted. This same study concluded that the trait locus for anxiety was higher in autistic populations and may contribute to stereotypic behaviors. Serotonin levels increase after exercise (17) and could provide the stimulus the child normally receives from the SSB contributing to the decreased behaviors after exercise (2). Perhaps exercise also improves uptake, minimizing serotonin accumulation. Despite meta-analytic findings suggesting no statistically significant link between the serotonin gene transporter and autism, researchers acknowledged the sample size may be inadequate to detect a genetic association (19). However, more recent research in this area supports elevated blood serotonin as a biomarker in ASD (16). Furthermore, components of what geneticist believe are that the genes for autism and ADHD have been located on the same gene and even overlap in some regions, which leads to speculation that autism and ADHD may have similar physiology. Variations in the same gene may explain behavior problems associated with both disorders (36). Ritalin is a well-known drug therapy for ADHD that works as a stimulant to increase serotonin levels (26). Increasing serotonin may provide a calming effect for children with ADHD similar to that seen with exercise and ASD (2,35). It appears there may be a variety of physiological factors contributing to the decrease in stereotypic behaviors after exercise yet more research is needed to quantify these mechanisms.

ASD has varying levels of severity as well as developmental paths (3). Limitations of our study include a lack of distinction between the severity of the disorder affecting the individual child with ASD. Future studies are needed to examine distinctions between the effects of exercise on varying classified severity levels of autism and to determine the benefits of a physical activity–based intervention program designed to reduce SSB. An additional potential limitation is the use of more than one modality of exercise. Given the complications inherent to working with this population, we believe that it was appropriate to allow a degree of self-selection in the aerobic modality, particularly with the degree of control we had over intensity. The small sample size precluded any meaningful subanalysis of the effects of modality on behaviors, although future studies may consider this due to possible cognitive or coordinative differences. Furthermore, this study only analyzed the acute effects of exercise on SSB. One promising study by Bahrami et al. (6) found significant reductions in stereotyped behaviors after a 15-wk martial arts technique training intervention compared with preintervention levels, with improvements lasting up to 30 d cessation of training. Further studies are needed to determine the effects of exercise on SSB levels to prescribe such an intervention for long-term use.

Observations showing the sustained and even increasing effectiveness of low-intensity exercise in decreasing SSB support the notion that efficacy is not simply due to fatigue. Mechanistic underpinnings are beyond the scope of this investigation, and the pathway through which exercise may act to reduce said behaviors is still unknown. Changes in neurotransmitters or endogenous opioids are plausible means for mediation of this response. Observations from this undertaking may help guide this search, and further investigation in this realm is warranted. Designing an exercise program that matches the stereotyped behavior's motor pattern may be a practical method to encourage greater participation in exercise not only for the added health benefits but also for the potential to reduce stereotypical behaviors in children with ASD.

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