**Autism Spectrum Disorders and Exercise: A Brief Review**

Autism Spectrum Disorder (ASD) is very broadly defined by the American Psychiatric Association's Diagnostic and Statistical Manual, Fifth Edition as “a developmental disability with social communication deficits, social interaction deficits across multiple context, and restricted repetitive patterns of behavior” (3). This disorder affects one in every sixty-eight children, which accounts for over two million individuals in the United States (1). When considering the population of the world as a whole, the number of individuals diagnosed with ASD is quite small. However, many of the repeated behaviors for this population are mostly sedentary in nature and cause concern for this population’s general physical health. Sedentary behavior has negative health consequences attributed in part, to motor impairments within some of this population that affects both fine and gross motor movement.

McDonald et al. (24) studied the correlation between the muscle motor deficits and their social skills. They used an IQ test and a gross motor development test on thirty-five subjects and found that even though the motor skills had no correlation to social skills, that motor skills were strongly correlated with the severity of the individual’s Autism (24). This is important to note: if social skills and motor skills correlated, then it would be easier to understand why this population might be discouraged towards exercise. However with only one study completed, it is hard to draw definitive conclusions.

 Before getting to the possible inhibitors or the benefits of exercise, it is important to determine whether or not there is any cause of concern regarding the physical health of this population.

***Obesity/Sedentary Behavior and Autism***

It is important to understand the current state of physical health in individuals with Autism. During 2011-2014, the percentage of individuals in America living with obesity was estimated to be about 36% for adults while children were estimated at 17% (3, 33). Zuckerman et al. (50) found that out of 367 children with ASD, that the obesity rate for that study was also 17%. Even though this number is consistent with the national average, it is important to note that this sample size for this study was comparatively small compared to the sample size for the national average. Unlike the national numbers, Zuckerman et al. (50) did not find any differences when looking at correlates like socio-demographics. This study’s numbers should not diminish the fact that a seventeen percent obesity rate, no matter the population, is way too high of a number for children in general.

C.Y. Pan. (39) found a significant difference between children with Autism and their peers when both groups took a motor proficiency and fitness test. The difference was that the children with Autism scored lower on all testing criteria on the BOT-2 tests, with overall score lower by 12.55 points (39). Pan & Frey (40) examined physical activity patterns of youth with Autism. Thirty-Five subjects with Autism wore an accelerometer for a week. The results showed that the younger children reached recommended time spent in moderate to vigorous activity but as age increased the amount of physical activity decreased (40). Another study (36) concluded that only 46% of 35 school aged children with Autism got at least 60 minutes of moderate to vigorous physical activity (MVPA) in physical education class, with the majority of the percentage coming from the elementary aged children, using data collected from accelerometery. The percentage found that non-ASD children had the same percentage of children obtaining MVPA during physical education. The study also concluded that during recess, children with ASD had a lower percentage of time spent in MVPA than their non-ASD peers, with percentages being 27% to 37%, respectively (36). The last conclusion from this study was that physical activity levels during school time for both students with and without Autism, mainly happened during physical education class. Even then, the students were only physically active for about half of the time spent in class (36). This study showed that when compared to their peers, children with ASD have trouble obtaining MVPA when the activity is not structured.

Two studies examined time spent in MVPA by school aged children and children aged from 7 to 12 in school with and without Autism concluded that: children with Autism spent eight less minutes in MVPA than non-ASD children (35). More time was spent in morning recess by children without Autism and the least physically active were the younger students with ASD (35). All children showed increased activity during physical education (41), that recess was a more physically active time than lunch for students (41), and physical activity decreased after school (41). These studies suggest that the students with Autism showed overall less time in this state than their peers. A similar study (48) showed the same results regarding physical activity, but also showed significantly lower strength, but not for VO2, body fat percentage, and flexibility, among individuals with Autism compared to their peers. The difference being the children with Autism scored lower. Another study (34) examined heart rate response of children with Autism compared to their peers in response to physical activity. This study concluded that not only did individuals with Autism have a lower heart rate response to activity, but scored lower than their peers in all the physical activities that were measured such as: Flexibility; Hand grip; Reaction speed; Eurofit Sit Up test; Vertical jump test; Broad jump test; overall speed, and speed on a motor educational course (34) . However, another study saw no difference in heart rate profiles between individuals with Autism and their peers (6).

These studies concerning the current state of overweight/obesity prevalence in this population showed that compared to the overall population, there is not any evidence that shows that there is any more of a reason for concern than the already existing one for the majority of the entire population. Even though there is no added concern about the ASD populations’ obesity prevalence, it is still important to see what maybe inhibiting people with Autism from getting the proper amount of exercise.

**Possible Inhibitors of Exercise**

As previously stated, being physically active for individuals in the Autism population may be due to repetitive behaviors that are more than likely sedentary in nature. However, there may be other reasons that may inhibit these individuals from being physically active. The reasons needs to be stated in order to fully understand how to help this population become more physically active and to prevent the adverse effects of being physically inactive, like obesity and diabetes.

One reason for reduced MVPA in those with ASD is motivation. This study by Tsai (47) found that when comparing adolescent children with and without Autism, the children with Autism showed significantly lower scores in motivation when using a modified version of the Motivation in Physical Education Scale (MPES) (47). The children with Autism: were perceived to be less competent, with an average score 1.32 points lower; showed to be less intrinsically motivated, with an average score 1.38 points lower; showed that being physically active during P.E. class was not personally important, with an average score 1.14 points lower; showed less of introjected and identified regulation , with an average score 2.31 and 1.17 points lower respectively; showed overall less effort to engage in activities, with an average score .97 points lower; and that self-determination was lower, with an average score 6.46 points lower. All major differences were found to have a p value of <.01.

Must et al. (29) investigated the barriers that parents perceive reduced MVPA in their ASD children. The barriers found were: perceived social skills, with 77% of parents saying their ASD kids social skill deficit was considered a barrier to physical activity, while 1% of parents said their non-ASD kids had the same barrier; perceived lack of friends (45% to 0%); family time affected physically activity (32% to 17%); perceived behavioral issues (52% to 0%); learning difficulties (37% to 1%); poor motor skills (41% to 1%); activity is too stimulating (26% to 0%); too much supervision required (60% to 0%); arrangement difficulty (34% to 3%); not knowing how to include child in activity (58% to 1%); children excluding others (22% to 0%), and that opportunities for physical activity are unavailable (32% to 0%) (29).

M.K. Johnson investigated (18) physical motor impairments as a possible inhibitor of exercise among this population. The study was conducted by interviewing parents of kids with special needs over a telephone call. This study consisted of over 40,000 participants. The study found that movement issues may be an indicator of Autism and that those with Autism may have difficulty using their hands compared to other special needs children (18).

The last reason for this population being physically inactive that was examined in the literature, was whether social interaction carried a positive or negative effect when it comes to physical activity. There were two studies that investigated this with the idea that with social interaction being a difficulty for individuals with Autism that it may be a reason for lack of physical activity. Both studies showed that both affected each other positively (37, 42). These studies also concluded that interaction with peers had a greater positive effect on physical activity than interaction with adults (37, 42). It can be said from these two studies that just being included in activities with their peers, individuals with Autism can improve their physical activity levels.

From the studies examined on what the possible inhibitors of exercise may be for this population, it is seen that motivation, resources, and muscular impairments are the most common inhibitors for the ASD individuals to obtain the proper amount of exercise. Since it is now known that the ASD population has different inhibitors than the rest of the population, it is important to see what other benefits exercise may have for those with ASD.

**Benefits of Exercise**

Exercise can produce numerous benefits for people in general, and could produce even more when a group of individuals are considered unique. The majority of the studies that examined the beneficial effects of exercise for this population were not just focused on improving muscle motor deficits, even though a study did show that children with Autism may have a hand strength deficit (20), but also on focusing on tasks, minimizing/stopping certain repetitive and/or abhorrent behavior and other benefits.

A good amount of research found examined how exercise affected stereotypy (behavior deemed typical of individuals with Autism) and/or problematic behavior for individual in this population. Two studies used “Kata techniques” as an intervention when trying to improve behavior. Both studies used control and experimental groups and had sessions lasting at least thirty minutes. Both studies also used the Gilliam Autism Rating Scale (4, 28) to evaluate any behavior change. The studies concluded that with a routine exercise program (in this case Kata technique classes) that individuals with Autism can reduce their social dysfunction in this population. One study showed an improved score with the experimental group having a reduction in social dysfunction with a score of 6.38 points after intervention compared to only a reduction of .15 points in the control group (28). The other “Kata techniques” study showed a reduction within the experimental group of a score of 5.33 points after intervention compared to only a reduction of .53 points in the control group (4).

A third study used a Chinese mind-body exercise, called “Nei Yang Gong”, to see if this kind of exercise could reduce problematic behavior. The study lasted one month with each session lasting from 5-45 minutes with 46 children in either the experimental or control group. Data was collected using the “London Tower Test”, the “Children’s’ color trails test”, and the “Five point test”. The most important benefit found was the reduction of problematic behavior, with the experimental group scoring on average 1.49 points lower after intervention while the control group scored an average of 2.46 points higher after the month (lower score indicated less occurrence of problematic behavior). Other benefits were improved self-control and enhanced brain activity (9). Magnussen et al. (25) used clinical exercise testing to determine what the effects would have on fitness and behavior. This was study had six subjects, but was very thorough in using a behavior assessment of each individual. The program lasted eight to twelve weeks and was conducted two days a week and consisted of exercises that involved high-intensity interval, aerobic, plyometric, and resistance training aspects. The same clinical tests and behavior assessment were administered after the completion of the program. The results were: that means for all fitness tests improved, with cardiorespiratory fitness going from a 1.76 to a 2.34 (mL/kg/min), curl ups going from 15.5 to 30.7, sit and reach from -14.3 to -9, push-ups going up from 6.75 to 13.75, bench press going up from 16.5 kg to 19.5 kg, leg press going up from 50 kg to 61.7 kg; that positive behaviors (academic performance, attention to task, social skills) with means scores increasing in frequency from 5.33 to 7.17 and 4.5 to 7.17 and 4.5 to 6.5 respectively; and problematic behavior (self-stimulatory behavior, self-harm, physical aggression, and verbal aggression) decreased in frequency from 5 to 3.5 and 3 to 2 and 2.33 to 1.33 ad 3 to 1.83 respectively(25).

Pan (38) examined exercise as a way to improve problematic behavior using water exercise. This study had two groups that alternated being the experimental group. The study lasted for twenty weeks total, with each group having two 90 minute sessions each week for ten weeks. The study used the School Social Behavior Scales to measure behavior before and after the program. It was concluded that the program reduced problematic behavior (hostile/irritable, antisocial/aggressive, defiant/disruptive, and total antisocial behavior) with mean t scores decreasing 7.72 and 5.73 and 8.19 and 7.35 respectively (38). Neely et al. (30) examined the utility of exercise in improving stereotypical and/or problematic behavior. Exercise being used before two children did academic work. The exercise was jumping on a trampoline for twenty percent less time than the children’s satiation time and was done for ten minutes sessions two to three days a week over a ten to twelve week period. The study found that antecedent exercise can reduce stereotypy with one of the children having a percentage of intervals with 34% stereotypy after exercise and 66% stereotypy after no exercise. The other child having a percentage of intervals with 12% stereotypy after exercise and 28% stereotypy after no exercise (30). This study also found that exercise had no effect on academic engagement.

Studies have examined exercise as a way to improve academic engagement. The first study (31) used four students who jogged for twelve minutes before entering an academic setting. The researcher used the Behavioral Observation of Students in School and categorized engagement into either active or passive time. This study concluded that exercise time correlated with active engagement time, with an effect size for the students of -2.6, -1.5, -.9, and 1.05, respectively (31). However another study that looked at academic engagement with a larger sample size of 24 subjects, found no significant improvement to academic engagement after exercise (33). The third study looked at exercise (perceptual motor training) as a way to increase the attention span in the ASD population. This study had an experiment and control group consisting of forty children total and lasted for eight weeks with sessions four days per week. The researcher used the Lincoln-Ozertesky motor skills test, the Continuous Performance tests, and others to get baseline strengths and weakness and intelligence. The results were that the experimental group scored higher mean post-test scores than that of the control group, with the differences being 8.15 points higher for the experimental group and .65 points higher for the control group (2). With the few studies done looking at academic engagement or attention, it is hard to tell if exercise can improve this area of concern for this population. What is known is that this is an area that needs more research.

The next group of studies examined whether the impact of exercise could improve muscle motor impairments in the ASD population. Cheldavi et al. (8) examined the impact of balance training on balance deficiencies within the ASD population. The study used twenty subjects split into a control and experiment group, with the experiment group training for three sessions a week, forty-five minutes a session for six weeks. The study concluded that a simple postural balance training program can benefit this population in regards to obtaining the proper core stability (8). Hawkins et al. (17) examined the effects of equine therapy on overall gross motor skill. Subjects rode for three times a week for thirty minutes for up to five weeks. The results showed that body coordination improved, with one subjects baseline coordination score rising from ranking at 62% to 83%, and the others score improving from ranking at 10% to 87%. Gross motor composite scores, also improved with one subject increasing their ranking from a score of 33% to 66% and the other improving from a ranking of 3% to 31% (17). The last study examined a group swimming exercise on fitness in this population. The study consisted of two groups, one was the intervention group and a wait list intervention. The intervention consisted of 40 minutes in the pool, twice a week for 14 weeks. The results showed that the intervention group showed significant increases in water skills, with 1.71 mean level higher on the Swimming Classification Scale and an improved mean score of 8.72 points on the YMCA water checklist, and muscular strength(curl ups and isometric push-ups), with improvement in scores of 5.43 repetitions and 8.14 seconds. (13)

Goodarzi and Hemayattalab (16) studied the effects of exercise and calcium intake on bone mass density, stating that this research has not been done with consideration for the special needs population. This study took 60 subjects in four different groups. These groups were: exercise and calcium, exercise training only, calcium intake only, and control/neither. This study went over a six month period and the groups that exercised did so for 3 days a week while the groups taking calcium took an additional 250 mg of calcium a day. The results showed that all experimental groups showed significant increases in bone mass density with the group doing exercise and supplementing calcium showing the highest increase in bone mass density (16). Two studies (14, 15) examined at how leisure programs, that were not necessarily exercise, had an effect on ASD individuals quality of life. Both studies used experimental and control groups. The studies also used similar tests to collect data and had the experimental groups take part in chosen leisure activities for two hours a day, five days per week for a year. Garcia and Datillo (14) found that a leisure program integrated into an ASD individual life’s can reduce stress, with a mean score reduction of 10.84 points, and increase quality of life, with a mean score higher by 13.03 points (14). Garcia and Datillo (15) found that a leisure program can also improve cognitive function (“Tower of London test”) of individuals with Autism, with individuals increasing their score by a mean of .92 points and reducing time on test by a mean of 3.95 seconds (15). These studies indicated exercise may be effective in improving the quality of ASD individuals’ lives.

**Guide to Exercise Implementation**

Since most studies have shown exercise can benefit the ASD population, it is now important to develop effective methods for increasing exercise. This is important because ASD individuals may not be able to understand the importance of exercise verbally. These following articles provide some guidance in how to get the ASD population exercising now and for the rest of their lives.

The first few papers address certain concepts and concerns for a person teaching exercises for this population. One paper discussed six key rules that could help when working in a fitness aspect with this population. They were to: use visual supports (a lot of individuals learn by visual aid); use short and concise language (literalism is common in ASD population); choose clothing wisely (possible sensory problems); location (least restrictive environment); and if an individual cannot do something due to a sensory issue to find a way the skill can be done with accommodation (5). Another paper lists some possible issues one may encounter while teaching exercises to this population. The issues are: avoidance of the exercise; escape from the area; self-harm; and physical aggression (10). These are important so an instructor can prepare when it comes to teaching the ASD population exercises. This paper also makes a case that the major areas of focus for exercises needed are pushing, pulling, squatting and rotational movements that build strength and stability like all other populations within society (10). Another paper talked about the motor deficits within this population. Stating that about 80% had definite motor skill issues. The article then suggests that motor planning is also an issue in this population. Motor planning is knowing what the body is to do, but being unable to perform the task. Using a mirror teaching technique may help with this issue (45). Crollick et al. (11) provides some approaches to increasing physical activity in this population. The paper suggests exercise should: be pleasurable, voluntary, it has no end in life, and it is flexible and changing (11). This paper also states some objectives when teaching this population. These are to include cardiovascular activities, use locomotor activities, implement activities that involve decision making, and to always be encouraging and constantly praising (27). Knowing all of this information for these concepts and concerns can greatly improve the success teaching exercise to an individual with Autism.

Two papers examined different physical activities that may help the ASD population become more active. The first paper discussed yoga. The paper discussed setting up a proper environment that will not be too sensory loaded for any individual’s sensory issues or unsafe for anyone performing yoga (12). The paper then goes on to say that it is important to start with a breathing exercise to reducing of the anxiety that many in this population feel throughout the day. They also suggest that using exercises that are on the ground are the best for beginners, since many individuals with Autism may have postural control issues (12). The second article discussed improving fitness of this population through a bicycle training study. This study examined how using an adapted bicycle could help individuals learn to ride a two wheeled bicycle. The study saw that 80% of the 43 subjects learned to ride a bike and the majority of success was due to older age of individuals, who had a longer and stronger body (26). This study showed that riding a two wheeled bicycle may not be the best form of exercise for the ASD population when introducing exercise early in an ASD individual’s life. Lee and Porretta (23) discussed using an aquatic setting to help improve fitness in the ASD population. The article portrayed advantages of reducing the impact gravity could help individuals learn skills without the risk of falling (23). Starting out learning some basic exercises could also increase adherence, since falling down reduces desire to continue the activity.

There was only one actual study that looked at using exercise as a way to improve the health of this population. This study evaluated whether a simple walking program could improve the health of ASD individuals. The study used four subjects who wore a step counter for 42 days and were given incentives to achieve daily step goals of 10,000 steps. The results showed that with incentives and encouragement all subjects reached the daily step goal of ten thousand steps (21). Even with a very small sample, this study suggests that you can increase the physical activity of individuals with Autism.

**Other Reviews/Meta-Analysis’s**

 With the literature being so small for such a broad topic, there were only three reviews that have been done. The first two reviews were done by physical therapists. Each article was broken into sections similar to this paper. The chief conclusion of the first article was that when working with this population, it is very important to understand whether the individual is epileptic, and their cognitive level (46). The second article reported a study that showed children with Autism are 6% more obese than their peers and that some individuals in this population may have metabolic abnormalities due either to their condition or the medication that they are taking (44). The third review of the ASD exercise literature focused mainly on studies that looked at exercises with this population. This review looked at eighteen different studies with a total of only 64 subjects. The studies mainly involved walking or running as the intervention and the exercise led to improved: behavior, academics, physical fitness, and exercise behavior (22).

 The last two articles were meta-analysis. The first meta-analysis found that of the studies reviewed, the majority were reliable with an overall improvement of at least 37% in behavioral and/or academic crtieria. This article found that even though both group and individual exercise resulted in great improvement, the most occurred in individual exercise sessions (44). The second analysis looked at the quality of studies that examined the effects of antecedent exercise on self-stimulatory behavior. The analysis was of twelve different studies, two with a group and ten with a single-subject design. The result was that the majority of studies examined lacked the quality indicators to include these studies as evidence for determining best practices with 37% of quality indicators not met by either study (19).

**Conclusions**

In summation of all the literature, several outcomes can be determined. The first outcome is that there is little research concerning ASD and exercise and more research is needed to make better conclusions regarding some of the questions. The second is that there could be cause of concern for this population’s physical health with the possibility for individuals becoming obese, diabetic, or getting a cardiovascular disease due to inactivity. The third is that there is real concern to what may be inhibiting this population regarding exercise and there needs to be more access to exercise so that ASD individuals can receive all the benefits. The fourth is that there are some obvious benefits, such as: improved overall behavior; reduced stereotypy behavior; reduced problematic behavior; increased socialization skills, and increased cognitive function. The final conclusion is that there are already some great guides in the literature to help professionals teach exercise to this population, but there needs to be an updated guide incorporating current research.

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