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Increasing Exercise in Individuals with Autism Spectrum Disorder: A Systematic Review of Instructional Strategies

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Increasing Exercise in Individuals with Autism Spectrum Disorder: A Systematic Review of Instructional Strategies

by

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APPROVAL FOR SUCCESSFUL DEFENSE

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Abstract

It has been found that children with autism spectrum disorder (ASD) are 1.6 times more likely to be obese compared to neurotypically developing children. Individuals with ASD often struggle with motor skills and experience sensory processing difficulties, which can make it difficult to participate in regular physical activity. Because of this, it is crucial to find exercise methods that are enjoyable, practical and that are tailored to the specific needs of individuals with ASD in order to help them maintain a healthy lifestyle. The current systematic review investigated the research literature on interventions used to teach exercise to individuals with ASD and investigated if there is enough research support to consider any interventions as evidence-based practice. 14 studies met the inclusion criteria, and their data were extracted and examined. While results were promising, the overall review indicated a need for more consistent treatments for teaching exercise so that further research in evidence-based practices can be established. Future directions for research were postulated.

Key words: *Autism, exercise, physical activity, systematic review*

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Obesity is a significant global issue that affects millions of people worldwide. It is a condition that can lead to various other complications such as heart disease, stroke, diabetes, and cancer (World Health Organization, 2021). It is an issue that is especially prevalent in autistic individuals as they encounter many challenges that can make weight management difficult (Curtin et al., 2010). Autistic individuals face problems with social communication, sensory processing, and motor coordination, all of which can play a large role in hindering their ability to participate in many naturally occurring exercise scenarios (Ming et al., 2016). By examining established methods for teaching exercise to individuals with ASD, we can determine which treatments are most effective for this population. Regular exercise has many benefits to the physical and mental health, including reducing anxiety, decreasing weight, and enhancing motor skills (Bodde, 2009). Because of this, it is crucial to find the most efficient and effective interventions to help autistic individuals increase their engagement in exercise.

Diagnosis and Characteristics of ASD

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that often features impaired social interaction and repetitive patterns of thoughts and behaviors ranging from mild to severe. (American Psychiatric Association, 2013). The Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) criteria for ASD include two core areas: social communication and interaction, and restrictive, repetitive patterns of behavior (American Psychiatric Association, 2013). For an individual to meet the diagnostic criteria, they must show persistent deficits in social communication and social interaction, which can include difficulties with back-and-forth conversation, nonverbal communication, and difficulty developing and

maintaining relationships (American Psychiatric Association, 2013). They must also demonstrate at least two restricted, repetitive patterns of behavior such as repetitive motor movements, insistence of sameness, or highly restricted, fixated interests (American Psychiatric Association, 2013). These symptoms must be present in the early developmental period and must cause significant impairment in a social or occupational area of functioning (American Psychiatric Association, 2013). The severity of ASD is based on the degree of impairment in social communication, social interaction, and restricted repetitive patterns of behavior, as well as the amount of support required (American Psychiatric Association, 2013).

ASD is typically diagnosed by a healthcare professional, such as a pediatrician or psychologist, who specializes in developmental disorders. The diagnosis is usually based on an evaluation of a child's behavior and development (American Academy of Pediatrics, 2019). This can be done through interviews with family members in combination with direct observation. There is no single test for ASD, so the process of diagnosis involves the use of a combination of assessments and observations.

There are early signs for parents to be aware of, including delays in language development, difficulties in social interaction, and repetitive behaviors (American Academy of Pediatrics, 2019). One of the earliest assessments that pediatricians will use to screen for autism is the Modified Checklist for Autism in Toddlers Revised (M-CHAT-R), which is a series of interview questions for the family and is given between 16 to 30 months of age (Lord et al., 2018). Another assessment instrument which is frequently used to assess for autism is the Autism Diagnostic Observation Schedule Revised (ADOS-R). The ADOS-R is a semi-structured assessment designed to evaluate social and communication skills, as well as repetitive behaviors in individuals who meet criteria for having autism spectrum disorder (Lord et al., 2001).

Observations and assessments may take place in the home, in a school setting, or even in the community. In general, the diagnosis of ASD is made by looking at many aspects of a child's life in many different areas to assess their overall functioning and cognition.

Early intervention for children with autism is very important because it can lead to better long-term outcomes (Rogers et al, 2008). Early identification and intervention can improve social communication skills, cognitive functioning, and behavior. (Dawson et al., 2010). Early intervention can also help with developmental delays and, in turn, improve academic performance. It can also lead to better adaptability to social situations and environments. Because brain development in childhood is malleable, early intervention can more easily promote positive outcomes the earlier they are initiated (Dawson et al., 2010). This can help to lower the severity of ASD symptoms, which can help to prevent long-term deficits in autistic individuals (Dawson et al., 2010). Therefore, early identification and intervention is critical to developing a plan of action and route to success for the child. It can help children develop the necessary skills to reach their full potential and increase their capabilities.

While individuals with ASD often have unique strengths and abilities, they may also experience physical and intellectual deficits. Autism characteristics can vary widely in severity and presentation. For example, while some individuals may have issues with executive functioning and working memory, others may show issues with coordination and balance (American Academy of Pediatrics. 2019). Autistic individuals may also face difficulties in adapting to routines and can maintain specific interests and fixations that are highly restricted (American Psychiatric Association, 2013). These deficits can have significant impacts on daily functioning. Because of this, individuals with autism require targeted interventions as well as specific accommodations to support them achieving their functional living goals. Individuals

with ASD tend to learn things differently than neurotypical individuals due to their unique ways of processing sensory information (Attwood et al., 2003). Because of this, individuals with ASD may have difficulty with language-based instruction and abstract concepts (Attwood et al., 2003). However, they may excel with hands-on or visual-spatial learning tasks due to their different style of processing (Attwood et al., 2003).

Individuals with ASD often face communication deficits that can lead to difficulty expressing themselves and understanding others. Language development is often delayed, and speech impairments are commonly observed. These deficits are seen in challenges with nonverbal communication such as facial expressions and body language as well as in difficulties with grammar and vocabulary (Butler et al. 2013). While these communication deficits are a large part of ASD, there are many other common features, including difficulty with executive function, which relates to things such as completing tasks and organization (Mandy et al., 2012). Along with this, come struggles with the use of language in social contexts, such as understanding sarcasm or jokes. Individuals with ASD may also exhibit challenging behaviors including aggression or self-injury when they are overwhelmed or unable to communicate effectively (Mandy et al., 2012). While all these features can be seen, not all individuals with ASD will exhibit them and each person with ASD can experience different outcomes. Children with ASD frequently also show symptoms of hyperarousal including anxiety, mood swings, and impulsive anger (Ming et al., 2016).

People with ASD experience a wide range of health-related issues. ASD is a large risk factor for obesity in individuals of all ages as studies have shown that children with ASD are more likely to be obese than neurotypical children (Elias et al., 2019). That trend continues into adulthood as well as there are several risk factors associated with this increased rate of obesity

including lack of physical activity, sedentary behavior, and atypical eating habits (Elias et al., 2019). Sensory processing issues can lead to problems with sleep, gastrointestinal issues such as constipation, and even seizure disorders (Matson et al., 2011). Autistic individuals also can have difficulties with communicating their symptoms and needs, which can make it difficult to diagnose and treat health issues efficiently and effectively. Difficulties with communication can also affect an autistic person's ability to participate in group activities and team sports. Communication skills are important for effective teamwork and cooperation as well as being essential to understanding and following rules for certain games and activities (Sowa, & Meulenbroek, 2012). Individuals with ASD may also struggle to share their thoughts and feelings, which can make it difficult to interact with teammates and coaches (Sowa, & Meulenbroek, 2012). They may also have trouble understanding social cues and norms which can make the social dynamics of team sports difficult to participate in (Sowa, & Meulenbroek, 2012). Other issues, such as mental health issues, including anxiety and depression, are also common for individuals with ASD, which can also have negative effects on their physical health (Matson et al., 2011).

Because of the many challenges faced by individuals with ASD in terms of motor skills and sensory processing difficulties, specialized healthcare is critical. In addition to healthcare support, teaching styles also play a large role in promoting success of individuals with ASD. Research has shown that teaching methods that incorporate clear instructions, visual aids, and breaking down tasks into smaller steps can be particularly effective in promoting learning for individuals with ASD (Wong et al., 2015). It can also be effective to use repetition and positive reinforcement to enhance learning (Wong et al., 2015). Successful interventions will vary person

to person as individuals with ASD all learn differently requiring individualized teaching styles in order to be effective.

Applied Behavior Analysis

One effective method of teaching individuals with autism is applied behavior analysis (ABA). ABA is the science of learning, which is based on the principles of behavior change, including reinforcement, punishment, and shaping (Smith et al., 2015). The goal of these principles is to break complex behaviors down into smaller steps that are gradually shaped through positive reinforcement to eventually lead to a desired behavior (Smith et al., 2015). This involves analyzing the variables associated with the smaller steps and adjusting the steps as needed.

ABA has been used as a therapeutic approach for individuals with ASD since the 1960s and has been shown to be effective in improving skills in communication, socialization, and adaptive behavior (Smith et al., 2015). ABA is a scientific approach to behavior modification. There were many key figures who laid the groundwork for applied behavior analysis. John B. Watson was known for his theory of behaviorism, which put emphasis on the importance of environmental factors on shaping behavior (Watson, 1913). He believed that behaviors were learned through a process of classical conditioning, where an association is formed between a neutral stimulus and a conditioned response (Watson, 1913). Another pioneer, Edward L. Thorndike, was known for his work on the law of effect, stating that a behavior is more likely to be repeated if it is followed by a satisfying consequence (Thorndike, 1898). This formed the theory of operant conditioning, which states that behavior is shaped through reinforcement and punishment (Skinner, 1953). Ivan Pavlov discovered classical conditioning when he paired the sound of a bell with a presentation of food to dogs, until the sound of the bell elicited salivation

in the dog, which previously was only elicited by the food itself. This means that he paired a neutral stimulus (the sound of the bell) to an unconditioned stimulus (the food) thereby creating a conditioned response to the previously neutral stimulus (salivation to the sound of the bell) (Cooper et al., 2020). B.F. Skinner's operant conditioning experiments utilized what is now known as a skinner box with rats and pigeons to observe how behaviors changed with different consequences. Positive reinforcement, or adding a desired stimulus, and negative reinforcement, removing an aversive stimulus, increased the likelihood of behaviors occurring again, while positive punishment, adding an aversive stimulus, and negative punishment, removing a desirable stimulus, decreased behavior likelihood. Skinner's research was pivotal to the foundations of how consequences shape behavior which helps to design effective behavior interventions in ABA. (Skinner, 1953). Once behavior analysis developed into a field of its own, Donald Baer, Montrose Wolf, and Todd Risley outlined the seven dimensions of ABA in their 1968 article "Some current dimensions of applied behavior analysis". They highlighted that for ABA programs to be successful they must be applied, behavioral, analytic, technological, conceptually systematic, effective, and generalizable (Baer et al., 1968). Expanding on the work of the behavioral pioneers, Ivar Lovaas is known for his work in the use of early intensive behavioral interventions, showing that young children with autism can improve developmental outcomes through intensive implementation of ABA principles such as shaping and reinforcement (Lovaas, 1987). In the years since, ABA has become one of the most widely used treatments for ASD and has effectively treated many behavioral and developmental challenges in autistic individuals.

Obesity in ASD

Obesity is a growing issue that is faced by more and more people every day. According to the World Health Organization (WHO), obesity rates have tripled since the 1970's, and today, there are over 650 million adults who are obese (World Health Organization, 2021). Rates of obesity in children and young adults have also increased significantly as 20% of this population is considered obese, and over 40% of adults are considered obese (Ng et al., 2014). There are many causes for obesity, including environmental, behavioral, and genetic factors. Other factors such as sedentary lifestyle, improper nutrition, and even excessive sugars in drinks can be major contributors to obesity (Ng et al., 2014). As mentioned previously, genetics can play a large role in the likelihood of an individual becoming obese. Because of this, it is important for caregivers and family members to do as much research as possible into their history to see which conditions their children may be more likely to contract due to genetic factors. Additionally, factors like stress, lack of sleep, and medications can contribute greatly to weight gain (Ng et al., 2014). With this, obesity can increase the risk of the development of other health conditions such as heart disease, diabetes, hypertension, and even certain cancers (Cawley et al., 2012). It is very important that obesity is treated in all individuals by first assessing it at the source, whether it be diet, lifestyle, genetics, or other factors to help obese individuals get on the track to a healthy mind and body.

Children with ASD are at an increased risk of being overweight/obese (Bicer & Alsaffar, 2013). A study from the Centers for Disease Control and Prevention found that children with ASD were 1.6 times more likely to be obese compared to typically developing children (Curtin et al., 2010). Another study found that 50% of adults with ASD are obese or overweight (Eaves et al., 2008). This is especially concerning as obesity can lead to many serious negative health outcomes including diabetes, cardiovascular disease, and certain types of cancer (Curtin et al.,

2010). Possible explanations for this are that individuals with ASD often have atypical eating patterns, limited physical activity, as well as using medications that can have side effects of weight gain such as anti-psychotic medications (Bicer & Alsaffar, 2016). In a study from 2015, it was found that mealtime difficulties were extremely common in children with ASD including food refusal, food selectivity, and disruptive mealtime behaviors. 70% of children with ASD were seen to have at least one mealtime difficulty (Sharp et al., 2015). Many studies have addressed this and found that food selectivity can interfere with the nutritional value of the diets of children with ASD (Zimmer et al., 2012). Food selectivity, also known as picky eating, was described by Klein and Nowak (1999) as showing aversions to certain textures, smells, colors, temperatures and even brands of food, all of which can make it very difficult to achieve a balanced and nutritional diet. This can present many risks to these children's mental and physical health that will follow them into adolescence.

As already noted, obesity is a common issue that negatively affects many children, adolescents, and adults, especially individuals with developmental disabilities such as ASD. This indicates that interventions to combat obesity are of utmost importance. Medical literature indicates that the best way to address obesity is through proper diet along with regular physical activity in a structured setting, commonly referred to as exercise (World Health Organization, 2021).

Treating obesity through exercise

Exercise has been shown to have positive effects on physical and mental health. It leads to improved cardiovascular health as well as strengthening muscles and bones (Janssen et al., 2010). Regular physical activity is also helpful for maintaining a healthy weight as well as reducing risk for diseases such as obesity, type 2 diabetes, and heart disease. It also promotes

greater sleep quality, enhanced mood, and increased energy levels (Janssen et al., 2010). For children and young adults, exercise also helps with development of social skills and the building of relationships with others through team sports and physical activity (Ginsburg et al., 2007). Exercise is a key part of a healthy lifestyle and plays a large role in the overall well-being of children and young adults.

While all exercise is important for the overall health of children and young adults, it is important that exercise is effective in producing results. In order to lose weight, a person needs to burn calories through exercise or some form of movement. Calories are burned through metabolism, which is how our bodies convert food into energy (Zurlo et al., 1990). When we engage in various physical activities or motor tasks, the body uses this energy. It helps with things such as breathing and circulation during exercise and allows us to push further and achieve more. The amount of energy needed to perform is what we refer to as calories. When we eat, we consume calories and usually consume more calories than our bodies need. The excess calories are stored as fat which can lead to weight gain (Zurlo et al., 1990). When we burn more calories than we consume, we are burning more fat for energy, which can lead to weight loss (Rosenkilde et al., 2017). Exercise is the most effective way to burn calories because it raises the body's metabolic rate, which allows you to burn calories both during and after a workout (Zurlo et al., 1990).

It is crucial to coordinate exercise programs to specific age groups and fitness levels so as to ensure that the intensity is appropriate for desired outcomes. For this, we look at intensity level. In children this means finding exercise that is developmentally appropriate, enjoyable, and engaging. Exercise intensity is the best determinant for the effectiveness of physical activity. The best way to find the correct intensity for any individual is to consult a healthcare professional as

they can provide advice to individuals and their caregivers about the best way to exercise to the right levels (American College of Sports Medicine, 2018). Finding the appropriate exercise intensity is an essential part of optimizing the physical health results of exercise and building the groundwork for future health and wellness, both physically and mentally (Pan et al., 2010). For young adults and older populations, it is important for there to be moderate to vigorous intensity workouts to achieve fitness goals (Pan et al., 2010). The American College of Sports Medicine recommends at least 150-250 minutes of moderate-intense physical activity per week for weight loss, which equates to about 30-60 minutes per day, five days a week (Donnelly et al., 2009). High-intensity interval training (HIIT) has been seen to be effective for weight loss as well, as it combines short bursts of intense exercise with periods of rest or low-intensity exercise (Donnelly et al., 2009). There must also be a balance of intensity in order to avoid injury and burnout and to help maintain optimal physical and mental health (Pan et al., 2010).

Because of the high obesity rate in autistic individuals, it is pivotal to incorporate regular physical fitness into the routines of children and adults with ASD to better curb the rising obesity rates in this population (Must et al., 2015). Whereas we know that a combination of proper diet and exercise is the best way to reduce obesity, there are many obstacles that make effective exercise programs difficult for children and young adults with ASD (Must et al., 2015).

Exercise and ASD

Current research suggests that individuals with ASD are less likely to engage in regular exercise compared to typically developing peers. A study by Must et al. (2015) found that only 28% of individuals with ASD met the recommended levels of physical activity compared to 64% of neurotypically developing individuals (Must et al., 2015). It has also been found that individuals with ASD tend to exercise less as they age. A study by Tyler et al. (2014) found that

physical activity levels of adults with ASD were much lower than children with ASD (Tyler et al., 2014). There are many possible explanations for this such as less access to the structured physical activity programs found in schools and increased responsibilities placed on individuals as they enter adulthood (Sowa & Meulenbroek, 2012). Despite the deficit in regular exercise compared to neurotypically developing peers, individuals with ASD who do engage in regular exercise see significant improvement in their cardiovascular health (Srinivasan et al., 2014). Regular exercise can also lead to reduced obesity in this population. Must et al. (2015) found that higher levels of physical activity were associated with lower rates of obesity in children with ASD (Must et al., 2015).

Individuals with ASD may find it difficult to participate in regular exercise due to a variety of reasons. One of the biggest obstacles is sensory processing deficits (Shanker et al., 2016). Individuals with ASD often find engaging in physical activity difficult due to sensory issues related to environmental factors such as noise, touch, and even bright lights which can all affect autistic individuals' ability to participate in regular physical activity in places like crowded gyms (American Psychiatric Association., 2013). Autistic individuals may be hypersensitive to specific sensory inputs, which can lead to discomfort, or they may be hyposensitive, leading to a lack of response from specific stimuli (Foley et al., 2018). These sensory issues can lead to many different behavioral challenges, including inducing agitation or avoidance of certain environments and activities (Foley et al., 2018).

Individuals with ASD may have motor coordination difficulties as well, which can make it hard for them to perform some motor movements and exercises. Motor coordination difficulties are a common challenge faced by individuals with ASD (Fournier et al., 2010). These deficits can affect gross motor skills including running, jumping, and kicking, as well as fine

motor skills such as using utensils and writing (Fournier et al., 2010). Children with ASD may also display some atypical motor movements including toe walking and hand flapping. These general motor coordination difficulties can impact participation in sports and other everyday physical activities which can lead to social isolation in some cases (Fournier et al., 2010). All of these factors can make it challenging for an individual with ASD to keep up a regular workout routine.

A big challenge in helping individuals with ASD to achieve fitness goals and successfully avoid things like hypertension and heart disease is proper motivation. Individuals with ASD often have specific interests and hobbies which can make it more difficult to find activities that they are motivated to engage in regularly (Foley et al., 2018). Another issue that can affect individuals with ASD is the lack of social motivation to exercise. There are many reasons for this, including difficulties with social interaction and communication as well as sensory sensitivities. As is the case for many individuals with ASD, team sports and exercise classes can be overwhelming and make participation difficult. These particular challenges can greatly impact individuals with ASD as it makes it very difficult to find an exercise routine that is sustainable and enjoyable, which can be a main deterrent of the social motivation to exercise (Levick et al., 2019).

All of these factors can cause a lack of regular physical activity which can lead to negative health effects such as obesity, cardiovascular disease, and poor mental health (American Psychiatric Association., 2013). Finding a way to motivate individuals can be particularly challenging, but there are some strategies that have been shown to be effective. One approach is to incorporate activities that individuals already enjoy. This could include a favorite sport, a type of music, or a preferred environment. Anything that can make exercise less of a task and more of

a preferred activity (Obrusnikova et al., 2011). Another way to increase motivation is to set achievable goals and continue to provide positive reinforcement throughout the activity in order to help individuals stay on track and develop a more positive relationship with fitness routines and fitness targets (Sowa et al., 2017). Another way can be to incorporate family members or peers into the routine as a way to provide social support, which has been seen to increase motivation and make exercise more enjoyable (Obrusnikova et al., 2011). Additionally, using technology like wearable devices and fitness apps can be a great way to track progress and provide immediate feedback which can make goals more visually attainable as well as showing progress at the same time. This is particularly helpful for individuals who work best with visual or auditory cues (Obrusnikova et al., 2011). By making exercise routines more in line with an individual's interests, we can help individuals who aren't typically motivated by exercise to be more involved and interested in achieving their fitness goals.

There are many other benefits of exercise for individuals with ASD as it can have a positive impact on physical, social and emotional health (Bodde, 2009). For example, exercise can lead to improved self-esteem and increased motor coordination (Bodde, 2009). Some individuals with autism may prefer repetitive exercises such as running or biking, while others may prefer group activities such as yoga or dance that can provide more structure and social integration (Bassette et al., 2018). It is important to investigate the various benefits of exercise for individuals with autism and to develop approaches to assist them in participating in exercise. Including physical exercise for individuals with ASD can produce many behavioral improvements, along with increased physical fitness (Sowa & Meulenbroek, 2012). A meta-analysis conducted by Lang et al. looked at 18 studies related to exercise, using activities

including jogging, biking, and weight training. The result of these exercises was a decrease in stereotypy, aggression, and elopement (Lang et al. 2010).

Obesity is a common comorbidity in autistic individuals, and regular exercise has been seen to be an effective intervention for treating obesity in this population (Must et al., 2015). However, people with ASD often face unique challenges when attempting to exercise or participate in physical activity, such as poor motor communication, difficulty with social communication, and sensory processing difficulties (American Psychiatric Association, 2013). Applied behavior analysis has been shown to be an effective way to teach autistic individuals, making it a potential method for teaching exercise to this population (Healy et al., 2017). Because of this, finding the most effective ways to teach exercise to the autistic population is extremely important as it can help to reduce obesity rates as well as improving overall health outcomes. Understanding and assessing the challenges that autistic individuals face when it comes to exercise can help to make exercise more accessible and enjoyable, which can lead to better health outcomes and greater quality of life.

Purpose of the Present Study

The purpose of the current systematic review is to explore the literature on instructional strategies for teaching and promoting exercise in individuals with autism. This systematic review is being completed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This is being done in order to determine if there are any instructional strategies that can be considered evidence-based practice for this purpose in this population.

Method

Search Methods

I conducted the initial search of the literature in October of 2022. The search was conducted using the Seton Hall library system multi-database search engine https://library.shu.edu/home. I used the advanced search option in order to find combinations of specific terms and so that the initial results could be filtered. The Seton Hall University library system searches through 617 databases simultaneously. Popular databases that are available include APA PsycArticles (EBSCO Publishing), APA PsycINFO (EBSCO Publishing), Education Database 1988-current (Proquest Central), ERIC (Proquest), Google Scholar, PubMed, SAGE Journals Online, Sciencedirect, Springer Journals, and Wiley Online Library. A list of databases included at the time of the initial search will be provided by the author on request. A general search was done using all available databases. My initial search was filtered in order to remove results that were not published in peer-reviewed academic journals as well as those not published in English. This search was not limited to certain years.

The following terms were used for my search: “autism” and “exercise”, “autism” and “physical activity”, “intellectual disabilities” and “exercise”, and “intellectual disabilities” and “physical activity” All searches were done within “All Text” in order to retrieve the most results. After obtaining the filtered results through the initial search, they were exported to Zotero, an online reference management software program. Zotero was used to remove duplicate results and organize articles that have been retrieved through the initial search quickly and efficiently. These results were then exported from Zotero into a Microsoft Excel spreadsheet for further analysis. Additional duplicates were then combed through and removed by hand after being exported into Microsoft Excel.

Inclusion and Exclusion Criteria

In order to obtain a final list of relevant articles that were subject to quality review, the following inclusion and exclusion criteria were applied:

Inclusion Criteria:

A. The article must be an empirical analysis of a treatment. This includes any study in which an independent variable, or treatment, is used and its effects tested on a dependent variable, or target behavior.
B. The study in the article must include exercise as a target behavior, or a dependent variable.
C. The study must have at least one participant, with a diagnosis of ASD.

Exclusion criteria:

A. Not an empirical study.
B. Not having exercise as a target.
C. Not having a teaching method designated to increase or teach exercise.
D. Participants did not have a diagnosis of autism spectrum disorder.

Data Extraction Procedures

The articles that met the previous inclusion and exclusion criteria were then examined by the following data extraction procedures: teaching method, target behavior, participant characteristics, effectiveness based on results, limitations, IOA data, generalization, and maintenance.

Quality Analysis Procedures

Single-case design studies included in this review were assessed using the quality analysis procedures used in Reichow (2011) for assessing single subject experimental designs (SSED). Reichow used six primary quality indicators (participant characteristics, independent variable, baseline conditions, dependent variable, visual analysis, and experimental control) and six secondary quality indicators (interobserver agreement, kappa, blind raters, fidelity, generalization or maintenance, and social validity) (Reichow, 2011). For each of the primary quality indicators, a study can be rated high (H), acceptable/adequate (A), or unacceptable (U). A high quality rating will go to a study that includes the following criteria for participant characteristics:

1. Age and gender of participants included.
2. Behaviors operationally defined and/or participants have a specific diagnosis via DSM-5 or other acceptable diagnostic assessment.
3. Characteristic information on researchers is provided.
4. If the study uses a standardized test, scores and measurement tools are provided.

An adequate quality rating is given when a study meets participant characteristics criteria 1, 3, and 4. An unacceptable quality rating is given when a study does not meet participant characteristics criteria 1, 3, and 4.

For the independent variable (IV), a high rating is received when a study defined their independent variable in a precise way that allows for replication (Reichow, 2011). If a manual for intervention is used in the study, then the study can be awarded this rating. An adequate rating is given when a study is able to define most of their independent variable but omits details that make the study more replicable. An unacceptable rating is given to a study that does not define their IV (Reichow, 2011).

For the dependent variable (DV) a high rating is received when a study meets the following criteria:

1. All variables are operationally defined.
2. The measures are detailed enough to be replicated.
3. The measures are linked to the dependent variables.
4. Measurement data are collected at appropriate times for the analysis conducted.

An Adequate rating is given to a study that meets 3 of the 4 criteria. An unacceptable rating is given to a study that meets less than 3 out of 4 of the criteria.

With regards to baseline data, a high rating is given when a study has all of the following:

1. Includes at least 3 measurement points
2. Stable data via visual analysis
3. No trend of counter-therapeutic trend
4. Operationally defined and replicable conditions

An adequate rating is received when a study has 3 of the 4 criteria. An unacceptable rating is given to a study with 2 of more criteria not met in baselines.

In the visual analysis domain, a high rating is received when a study has graphs that meet the following criteria:

1. Data are stable in level and/or trend.
2. Data contains less than 25% overlap of data points between adjacent conditions.
3. Have a significant shift in level or trend between adjacent conditions that follow implementation/removal of an IV.

An adequate rating was given when a study met two of the criteria for at least 66% of the graphs. An unacceptable rating was given to a study when two or less criteria were met for less than 66% of the graphs.

In the experimental control condition, a high rating is given when a study has an experimental effect occurring at three points in time with changes to the DV that vary with the implementation of the IV (Reichow, 2011). An adequate rating was given to a study that had an experimental effect on at least two points or at least 50%. An unacceptable rating is given to a study that has an experimental effect on less than two points or less than 50%.

When assessing the secondary quality indicators, a dichotomous scale (indicates if there was evidence or not) is used for each secondary indicator. Interobserver agreement (IOA) receives a positive rating if IOA is collected in all conditions, raters, and participants with a reliability above 80% (Reichow, 2011). Kappa (KAP) is given a positive rating when KAP is calculated for at least 20% of sessions across conditions, raters, and participants above 60% (Reichow, 2011). Blind raters are rated positive if the raters were blind to the IV. A positive rating is given in the domain of fidelity if the IV or procedural fidelity is assessed across conditions, participants, and implementers with statistics above 80% (Reichow, 2011). A positive rating is given in the domain of generalization or maintenance if data were collected after the final data collection in order to assess generalization or maintenance (Reichow, 2011). In the domain of social validity, a positive rating is given to a study that contains at least four of the following criteria:

1. Socially significant DV's.
2. Time and cost effective IV.
3. Comparison between individuals with disabilities and without.

4. Clinical significance by showing a behavior change.
5. Consumers pleased by outcomes.
6. IV is completed by people who interact with participants.
7. Study is completed in natural context.

Once the study is assessed for primary and secondary quality indicators, it is assessed an overall strength rating (strong, adequate, weak) which is given based on ratings received in quality indicators. A study is seen to be strong if it has all its primary indicators rated as high and its secondary indicators are high for three or more of the six indicators (Reichow, 2011). An adequate rating is given to studies that have a high rating in at least four of the primary indicators and an acceptable or high rating on at least two of the six secondary indicators (Reichow, 2011). A study receives a rating of weak if it has high ratings in less than four of the primary indicators and less that two high or adequate ratings in the six secondary indicators (Reichow, 2011).

The final assessment is to determine evidence-based practice (EBP) across the studies included using the strength ratings provided from the primary and secondary indicators (Reichow, 2011). Evidence-based practice has two levels of criteria, established and promising. An established treatment is one that is effective across multiple studies, by at least two independent research groups, that are all rating high across the possible combinations of evidence (Reichow, 2011). To receive a promising rating, the treatment must be effective across multiple studies and have aspects that show weaker ratings. Single subject experimental designs ratings must be determined by the number of studies conducted and number of participants used (Reichow, 2011). Another important aspect of the EBP determination is how many participants the intervention was successful for. The efficacy of these interventions is determined by using a formula that can assess all combinations of evidence (Reichow, 2011).

Results

The initial search of the full database resulted in the identification of 6,308 articles that met the initial search string criteria. This number is a result of combining the total articles found by searching four different strings. The search results were first limited to those that were peer reviewed, which led to a total of 3,756 articles remaining, with 2,552 articles being excluded for not meeting criteria. These results were then limited to only identify articles published in English, which resulted in 3,454 articles, with 302 articles being removed. The search then limited the results to only academic journals, which left 3,405 articles remaining, with 49 articles removed. The remaining articles were then uploaded to Zotero, leading to 1,115 articles remaining, due to the removal of 2,290 duplicates. These articles were then manually examined for duplicates which led to the removal of 320 articles, leaving a total of 795 articles for review.

Inclusion/exclusion criteria were then used to first remove all studies that were not empirical analyses of treatment, leading to 575 remaining articles with 220 articles being removed due to not being an empirical analysis of a treatment. The studies were then limited to only studies with exercise as the dependent variable, leading to a total of 268 articles remaining with 307 articles being excluded due to not having exercise as the dependent variable. The studies were then filtered to remove articles that did not feature a participant with a diagnosis of ASD, which led to a total of 124 articles remaining, meaning that 144 articles were removed due to not having a participant with a diagnosis of ASD. The studies were then filtered again to remove articles that did not have a behavioral teaching method as the independent variable, this led to a total of 14 articles remaining for data extraction and analysis with 110 articles being removed. Refer to Figure 1 for a visual representation of the search procedure.

After collecting and manually filtering articles based on inclusion criteria, IOA data were collected by a member of my thesis committee, which returned 94% accuracy for 20% of articles included in the review. This review involved a member of my thesis committee checking every 5th article in the database and applying the inclusion criteria to make sure articles that fit were included and those that didn't were not included. The IOA percent represents the total number of matches between my determination and the determination of my committee member, divided by the total number of articles selected for IOA.

Quality Analysis of Studies

Using the rating system provided by Reichow (2011), to assess the quality of single subject research, the included articles were assessed using primary and secondary indicators for single-case study designs. Results are displayed in Table 1. Seven studies; Bassette et al., 2018; Bassette et al., 2021; Becerra et al., 2021; Dieringer et al., 2017; Goldman et al., 2022; Park et al., 2020; Savage et al., 2018; and Savage et al., 2022) received an overall rating of "strong" and six studies; (Arslan et al., 2022; Fjellstrom et al., 2022; Kurt et al., 2018, Rotta et al., 2022; Todd et al., 2019; Yarimkawa et al., 2022) received an overall rating of "adequate".

11 of the studies included received strong ratings for having all of the primary quality indicators defined in their article; (Arslan et al., 2022; Bassette et al., 2018; Bassette et al., 2021; Becerra et al., 2021; Dieringer et al., 2017; Goldman et al., 2022; Kurt et al., 2018; Park et al., 2020; Rotta et al. 2022; Savage et al., 2018; Todd et al., 2019; Yarimkawa et al., 2022). Two of the included articles had one or more of their primary indicators rated as adequate (Fjellstrom et al., 2022; Savage et al., 2022). Table 1 shows the results of the quality analysis of primary indicators.

When assessing the secondary quality indicators, ten studies included interobserver agreement data. No studies reported Kappa and two studies (Savage et al., 2018; Savage et al., 2022) reported data for blind raters. Seven studies (Bassette et al., 2018; Bassette et al., 2021; Becerra et al., 2021; Dieringer et al., 2017; Goldman et al., 2022; Park et al., 2020, Rotta et al., 2022; Savage et al., 2018) reported generalization and maintenance data. Table 2 shows the results of the qualitative analysis of secondary indicators.

The results of this quality analysis show that the research included is relatively strong. Eight of the included articles were rated as strong, while the six other articles were rated as adequate. The included articles all scored very highly in their primary and secondary quality indicators, meaning that they included the necessary information to be considered adequate overall.

Participants

A total of 185 individuals participated in the included studies. Gender was reported in 100% of studies, with males making up 70.2% of the studies that provided gender information. Age was reported in 100% of studies, with ages between 4-57 years.

Research Design

Five studies used a multiple baseline across participants design; (Bassette et al., 2021, Dieringer et al., 2017, Fjellstrom et al., 2022, Rotta et al., 2022, and Savage et al., 2022). Two studies used a multiple baseline across behaviors design; (Kurt et al., 2018, and Arslan et al., 2022). One single-case alternating treatment designs (Savage et al., 2018). Four studies used a multiple probe design; (Becerra et al., 2021, Bassette et al., 2018, Goldman et al., 2022, and Park

et al., 2020). Two studies used a Pre-posttest intervention as the research design; (Todd et al., 2019, Yarimkawa et al., 2022).

Targeted skills for acquisition

Studies included in this review were selected due to their focus on increasing engagement in exercise and physical activity. Nine of the studies included focused on increasing engagement in health-related physical fitness activities; (Arslan et al., 2022; Becerra et al., 2021; Dieringer et al., 2017; Fjellstrom et al., 2022; Goldman et al., 2022; Savage et al., 2018; Savage et al., 2022; Todd et al., 2019; and Yarimkawa et al., 2022). Three of the included studies focused on increasing engagement in exercise through learning steps of an exercise or parts of a physical activity performed correctly; (Bassette et al., 2018; Bassette et al., 2021; and Kurt et al., 2018). One study (Park et al., 2021) measured learning of steps for shooting a basketball. One of the included studies focused on increasing engagement based on number of steps taken (Rotta et al., 2022).

Intervention procedures and reported results

While all of the identified articles looked to teach effective exercise to individuals with ASD, target behaviors and treatment procedures varied. In this section, articles are broken down into subsections grouped by the primary teaching method utilized by the researchers. The subsections include modeling, technology-based interventions, and prompting/reinforcement-based interventions. All of the articles were assessed based on effectiveness of treatment as well as limitations identified by the researchers. While these articles were grouped based on their general interventions, there was some overlap in the treatments due to the size of some of the

treatment packages. Therefore the articles were grouped based on what I determined to be the primary intervention strategy used in the procedures.

Modeling

Modeling is a behavior change strategy in which learners acquire new skills by imitating demonstrations of actions, by live or symbolic models, leading to reinforcement of the properly imitated demonstration. (Cooper et al., 2020). It can be used to teach a variety of skills depending on the needs of the individual. Modeling may be especially effective in providing exercise instruction due to its replicability and structured approach (Bassette et al., 2018). Four of the included studies (Bassette et al., 2018; Bassette et al., 2021; Dieringer et al., 2017; and Rotta et al., 2022) used modeling as the main method of teaching.

Bassette et al. (2018) evaluated the use of video modeling with prompting and reinforcement via an "exercise buddy" app on the percentage of steps performed correctly in an exercise activity. Three autistic individuals with a mean age of 18, and IQ scores of 55 or higher, served as participants. Prior to the study, all three participants were described as living a sedentary lifestyle with low levels of regular physical activity. The study involved participants using a video model included in a mobile app to show them how to properly complete a 'set' or a collection of repetitions of a specific exercise. As participants achieved the modeled skills, sets were systematically increased to allow for more repetition by the participant. Three of three participants increased their ability to perform physical activity exercises (squats, hip extensions, and dumbbell lateral raises) independently. A limitation of this study was that the authors did not employ a component analysis to determine the specific treatment strategies within the training package that were critical to the results.

Also using video modeling, Bassette et al. (2021) evaluated the effects of commercially available video models versus custom made video models on participants' ability to perform exercise independently in a community site. The intervention included participants exercising using both commercial and custom video models in an alternating treatment design and their results were compared based on percentage of steps in the exercise task analysis performed independently. The study included three participants with a mean age of 18 and diagnoses of ASD. Results indicated that video modeling increased exercise skills in all three participants with two performing more independently when using custom video models and one performing more independently using commercial video models.

Dieringer et al. (2017) evaluated the effects of verbal prompting and modeling with music on gross motor task completion (GMTC) in physical activity. The study included five participants between the ages of six and seven years old, all with a diagnosis of ASD. The study compared the impact of the presentation of music with lyrical instruction alone and with teacher modeling and verbal prompting on increasing GMTC. All five participants showed improvement in GMTC with the greatest improvements in GMTC obtained during the conditions with teacher prompting and modeling. There were some limitations to this study. The first limitation of this study was that receptive language skills and cognitive abilities were not assessed. The second, was that one-on-one physical activity sessions were conducted instead of group sessions, meaning that the results may not be generalizable to a classroom environment in a typical school. The third, was that verbal prompts and modeling were not evaluated in isolation. A final limitation was that increases in behavior did not generalize to novel stimuli (i.e., novel music).

Rotta et al. (2022) evaluated the effects of modeling and token reinforcement on number of steps taken and calories burned during five, 20-minute sessions per week over 13 weeks, for six participants, three male and three female, aged between 19 and 24. A classroom-wide treatment package was used that involved individualized daily choice (choice between dancing and strength training), modeling (live and video), and token reinforcement. This intervention was used to increase the number of steps taken and calories burned by six participants, as well as increase the percentage of students who were engaged in exercise during sessions. Results indicated that all participants increased the number of steps mastered and calories burned during both phases of the intervention (live and video model) compared to baseline. Maintenance sessions were conducted one week after sessions completed. Although only two participants were able to partake in the maintenance sessions, both were able to maintain their number of steps mastered and calories burned. A possible limitation of this study was that despite tracking the calories burned and steps taken, the researchers did not determine whether participants increased their strength or aerobic capacity due to the intervention. The researchers also noted that while maintenance data were collected, the maintenance phase had to be ended prematurely due to the school year concluding.

In summary, the articles discussed in this section all used modeling as the main teaching method for increasing exercise in participants with ASD. In these studies, modeling was shown to be effective as a teaching method for increasing exercise as 17 of the 17 included participants showed improvement in multiple areas of exercise including steps taken/calories burned, gross motor task completion, and percentage of steps performed correctly. These data provide evidence that modeling may be an effective teaching method in increasing exercise in individuals with ASD. It is interesting to note that three of the studies (Bassette et al., 2018; Bassette et al., 2021;

and Rotta et al., 2022) used video modeling in place of live modeling and skill acquisition was still demonstrated. This may increase the practicality of using modeling in natural settings when live models are not available or cannot provide repetitive modeling for discrete actions. Although modeling (both live and video) appears promising as a treatment for increasing engagement in exercise in individuals with ASD, the included studies all differed in their procedures and therefore, were not similar enough to conduct an assessment of empirical support. Some limitations of using modeling as a sole treatment for increasing engagement in exercise in this population are that generalization can be limited and results may not translate to different settings or contexts. Individuals may struggle to transfer learned skills from videos to real life exercises. There is also a potential limitation with motivation as some individuals with ASD may have difficulty maintaining attention and motivation when using video models without in person guidance.

Technology based Interventions

Technology is a resource that has become more and more popular within applied behavior analysis. Through technology, therapists can provide interactive and participant specific feedback and knowledge to make instruction more effective for the learner (Savage et al., 2018). There are various different ways that this can be done including apps that can track progress towards goals and provide up to the moment statistics on exercise data (Savage et al., 2022). Apps can also provide interactive prompts and instructions to help guide individuals in their workouts and interventions. The use of technology is valuable as it gives individuals the ability to gain insight from their therapist or instructor without them being present and can allow them to monitor their goals while exercising on their own (Savage et al., 2018). Five of the included

studies (Becerra et al., 2021; Fjellstrom et al., 2022; Savage et al., 2022; Savage et al., 2018; and Yarimkawa et al., 2022) utilized teaching methods involving technology.

Becerra et al. (2021) evaluated the effects of a photographic activity schedule on physical activity in three participants, one male and two females. All participants were four years of age and held diagnoses of ASD. The intervention involved the use of use photographic activity schedules to increase the number of moderate-to-vigorous physical activities (MVPA) completed during five conditions (fixed equipment, empty field, outdoor toys, indoor toys, and control). MVPA was low during baseline sessions but immediately increased with the introduction of the activity schedule. All three participants met mastery criterion and demonstrated high levels of MVPA. This study was limited by not equating the duration of teaching sessions across participants. Generalization sessions occurred after the initial schedule probe and after the no-schedule probe with the session being terminated after five min or the completion of the activity schedule. A maintenance session was conducted two weeks after final generalization session. This maintenance session ended after the participant completed the activity schedule.

Fjellstrom et al. (2022) evaluated the effects of a web-based training program called "MyMOWO" on physical activity level in 28 participants. Participants were 48% female with an average age 36.4 ± 9.56 years. The intervention consisted of a web-based training program that provided participants with instructions for completing a combination of exercises (endurance, strength, balance, and flexibility) of moderate intensity, for 50 min, three times per week for 12 weeks. The results found the intensity of the physical activity level increased and showed a decrease in fat mass in participants. One possible limitation of this study was that COVID-19 may have influenced participation in a positive way, due to less exercise opportunities being

available in the community or school settings for the participants. Another possible limitation was that the study did not control for food/drink intake.

Savage et al. (2022) evaluated the effects of supported self-management and Fitbit technology on increasing physical activity for 40 participants (70.6% male), with ages between 18-57 who were randomly assigned to a control and intervention group. The intervention group participated in the 12-week "Step It Up" program, which used self-management strategies and coaches who provided support, in order to increase the number of steps taken by the participants involved. The Fitbit was used in this intervention to show the participants their step counts and provide direct feedback to them throughout the program to show their progress relative to their targets. The control group also was given the Fitbit technology but did not participate in the Step It Up program and were just provided access to Fitbit step tracking and standard Fitbit resources. Participants in the Step It Up program had significantly higher average weekly step counts and lost more weight than the control group. Some possible limitations included small sample size, lack of standardized measures for confirming ASD diagnoses and frequency of contact between coaches and participants during the program not being measured.

Savage et al. (2018) evaluated the effects of praise statements both in-person and through technology on engagement in physical activity. The study featured three participants, all male, aged 20-22. The intervention involved an alternating treatment design which compared two conditions for delivering praise statements, in-person and through technology for the participants with the goal of increasing laps walked. The technologically delivered praise statements were delivered via headphones connected to an iPod nano that the participants wore during sessions. All three participants increased laps taken with positive results across both conditions. Some possible limitations included devices used to measure heart rate were not calibrated and, as with

all alternating treatments designs, one condition could have influenced performance in the other condition.

Yarimkawa et al. (2022) evaluated the effects of WhatsApp-delivered physical activities on physical fitness levels for 42 participants, 21 in the experimental condition (eight girls and 13 boys) and 21 in the control condition (six girls and 15 boys) with a mean age of 5.22 and diagnoses of ASD. The participants engaged in 6 weeks of the WhatsApp-delivered physical activities with the data being collected through Leisure Time Exercise Questionnaire (LTEQ) and Semi-Structured Interview Questions. WhatsApp-delivered physical activities included information, instructional strategies, and videos about physical activities that the parents of the participants would provide. Results demonstrated a significant increase in physical activity level but were limited by their small sample size and lack of follow up-assessment.

The articles in this section focused on technological approaches to teaching exercise to individuals with ASD. The forms of technology employed in the studies varied including photographic activity schedules, Fitbit monitoring of performance, app delivered activities for participants, praise statements delivered through technology, and a web-based training program that provided activities. All included studies found positive results, with 95 out of 95 participants experiencing an increase in physical activity engagement. Unfortunately, because forms of technology varied across studies, the data cannot be used to empirically validate the effects of any one intervention. In addition, several of these studies included a limitation of small sample sizes while others were also limited by their lack of maintenance assessment. Overall technology-based interventions were found to be effective in increasing exercise in individuals across all included studies. It would be beneficial for future lines of research to investigate the

effects of similar procedures and forms of technology so that an evidence-base can be established for specific technological interventions.

Prompting and Reinforcement Based Interventions

Prompting and reinforcement are techniques used often in applied behavior analysis (ABA) that have been demonstrated to be highly effective in teaching not just exercise but many other skills (Miramontez et al., 2016). Prompting involves providing assistance and cues to perform a desired behavior (Miramontez at al., 2016). There are different types of prompts including physical, verbal, visual, and gestural prompts, each of which can be beneficial to different skill levels of individuals (Hayes et al., 2013). Reinforcement is also crucial to teaching skills as it provides preferred consequences to desired behaviors (Goldman et al., 2022). There are many forms of reinforcement that can be delivered, including verbal praise, tokens within token economies, and tangible rewards (Goldman et al., 2022). These can all be effective in conjunction with prompting in providing structured teaching to a participant and encouraging them to perform the desired behaviors and reach their goals. Although the majority of studies identified in the current systematic review use some form of prompting and reinforcement within their procedures, five of the studies (Arslan et al., 2022; Goldman et al., 2022; Kurt et al., 2018; Park et al., 2021; and Todd et al., 2019) used simple prompting or reinforcement as the primary intervention.

Arslan et al. (2022) evaluated the effects of using most-to-least prompting during a 12-week exercise program on increasing running speed, agility, balance, standing long jump, reaction times, handgrip, and flexibility in 14 male participants with a diagnosis of ASD. They found significant improvements in these areas including a 30% greater mean growth in balance,

standing long jump, reaction time, and handgrip. The study was limited by not having measured the cognitive abilities of the participants prior to the intervention.

Goldman et al. (2022) evaluated a token-based intervention on physical activity engagement in four male participants, age eight, with diagnoses of ASD. Intervention included the delivery of token reinforcement for engagement in exercise when provided a choice of activities including trampoline, exercise ball, running, and playing soccer. The intervention started with a choice between remaining sedentary or engaging in one physical activity. Tokens were delivered contingent on engagement in physical activity increasing the motivation of the participants to choose physical engagement. After 15 sessions, additional physical activities were added with the highest ratio being 4:1 physical to sedentary activities. The therapists did not increase the ratio of physical activities available if the selection of physical activities did not increase during the 2:1 or 3:1 ratios. If the selection of physical activities did increase, then the therapist would continue to add activities until all were assessed or a preference was established for the participants. Results indicated that only two of the four participants increased physical activity. The study may have been limited by the number of physical activity options made available.

Kurt et al. (2018) evaluated the effects of most to least prompting on dynamic stretching exercises. The study featured four participants, all women, between 34-37 years old. The results showed most to least prompting method was effective in teaching dynamic exercise in all four participants. There were also increases in flexibility and balance of the participants in various ratios. Maintenance sessions were conducted two weeks after the end of the program to determine the extent to which participants maintained what they had learned. Results of the maintenance sessions found the participants were still preforming adequately.

Park et al. (2021) evaluated the effects of a peer-delivered simultaneous prompting procedure for the complex task of shooting a basketball. The intervention also looked to improve nontargeted content learning (Gross motor, fine motor) based on movements required to properly progress through steps of shooting a basketball. The study had four participants, two females and two males all between ages 12-16 with mild to moderate intellectual disability. The intervention involved daily trials consisting of an attentional cue, an instructional stimulus, a controlling prompt, a response, and a consequence. The session would include the peer tutor delivering a first step direction such as "hold the ball for 3 seconds with both hands" with a model prompt to demonstrate the step. After delivering the model prompt, the peer tutor would then ask the participant to repeat the step. If the participant performed the step correctly, the peer tutor provided verbal praise. If the participant performed an error, the tutor would deliver an error correction using the model prompt until the participant performed the step correctly. Results showed that all four participants improved in chained task of shooting a basketball, however only one of four participants improved in nontargeted content learning. A limitation of this study was that only three participants were able to participate in maintenance due to the end of the school year. The researchers also failed to conduct probe sessions for generalization.

Todd et al. (2019) evaluated the effects of peer mentoring on increasing physical activity and fitness in 16 participants, three females, and 13 males, between the ages of 18-28 with a diagnosis of ASD or Aspergers syndrome. The intervention featured a program called iFit, where college students with ASD were paired with a kinesiology student and would complete physical activities together for one hour twice a week. The kinesiology students were trained to provide physical activity recommendations, nutrition tips, and motivation through gaining competence in exercise fundamentals as well as being able to engage socially with peers. The kinesiology

students also helped the participants to choose exercises that fit their interests and physical needs. These targeted physical activities included weightlifting, treadmill and elliptical machines, and group games such as basketball. 30 percent of participants showed significant improvement in cardiorespiratory fitness and 25 percent increased upper body muscular endurance. Some limitations of the study include the small sample size, a possible lack of generalization because the study was employed only at one university, the absence of a control group, and an inability to assess effort level of participants.

Prompting and reinforcement are key principles of ABA. The articles in this section looked at using them as the main teaching method for increasing exercise behavior in individuals with ASD. While the exact treatments varied by study, they all featured reinforcement and prompting as the primary intervention strategy. Results varied with some studies showing effectiveness and others yielding less promising data. Arlsan et al., (2022), Kurt et al., (2018), and Todd et al., (2019), all demonstrated improvements in exercise activity by all participants while Goldman et al., (2022) showed effectiveness in only 50% of participants and Park et al., (2021) demonstrated all participants improving in shooting a basketball but only one of four improving in nontargeted content learning. This may indicate that while reinforcement and prompting are effective treatment methods in ABA, they may be best utilized in conjunction with other teaching methods in order to be most effective.

Discussion

Obesity is a significant global issue that affects millions of people worldwide. It is a condition that can lead to various other complications such as heart disease, stroke, diabetes, and

cancer. Obesity is an issue that is especially prevalent in autistic individuals as they face many challenges that can make weight management difficult. One significant challenge in helping individuals with ASD to achieve these fitness goals and successfully avoid things like hypertension and heart disease is proper motivation. These individuals tend to have hyper specific interests and hobbies which can make it more difficult to find activities that they are motivated to engage in regularly (Foley et al., 2018). Because of this, it is crucial to find the most efficient and effective interventions to help autistic individuals manage their weight and overall increase their engagement in exercise.

Exercise has been shown to have positive effects on physical and mental health. Regular physical activity has been seen to be helpful for maintaining a healthy weight and can reduce risk for diseases such as obesity, type 2 diabetes, and heart disease. Exercise also has been shown to have positive effects on social function in children with ASD. In a study conducted by Zhao and Chen (2018) they found that a 12-week structured physical activity program which included a total of 24 exercise sessions consisting of group exercises, led to an overall improvement in social skills and social interaction. In this systematic review, the literature base investigating the methods for increasing exercise in autistic individuals was examined. The initial search resulted in 6,308 identified articles and concluded with only 14 articles meeting all inclusion criteria.

While this review identified many different approaches to teaching exercise strategies for increasing engagement in physical activities, some interventions were more impactful than others. When assessing interventions related to modeling, prompting, and technological applications, all of the included interventions were effective in increasing engagement or teaching an exercise to participants with ASD. These studies showed that participants increased their engagement as well as their relative fitness and were able to maintain their engagement

through maintenance sessions for those that conducted them. Also, in some of the studies, it was shown that the skills learned were generalizable to more typical settings such as community fitness sites or gyms. While these studies provided promising results for increasing exercise, they all differed greatly from one another in their treatment procedures, which leads to difficulty in developing an evidence-base for any of the individual interventions. Therefore, I was unable to conduct an evaluation of evidence-based treatment as per Reichow (2011) on any of the specific treatments discussed in this review.

Besides data-based results, another aspect of an intervention that is important to assess is social validity. Social validity refers to the extent to which the target behaviors are appropriate, the intervention procedures are acceptable, and the important and significant changes in target behaviors are produced (Cooper et al., 2020). Social validity can be assessed in many ways but is often done using a questionnaire for the participants and caregivers or an interview following the completion of an intervention. Two of the included studies featured a form of interview or questionnaire completed by the participants' caregivers regarding their views on the procedures used in the studies and their results. Kurt et al. (2018) administered a semi-structured interview that assessed the views of teachers and parents towards the most to least prompting method used by the researchers with positive results. Bassette et al. (2018) also assessed social validity through a questionnaire administered before and after the intervention to the caregivers of the participants of their study. The results from the initial questionnaire indicated that all parents/guardians thought that the video models would help their children learn exercise skills and improve their overall physical health. Results of the post-intervention questionnaire shared that the parents/guardians thought the intervention increased their child's ability to exercise in various settings. Although results of the remaining studies were positive, social validity of the

interventions from the viewpoints of the parents and caregivers are unknown. This would have been beneficial for all researchers to assess and is encouraged in all future research in this area.

One problem that arose in the process of filtering articles based on inclusion criteria was the difficulty of determining whether exercise was being taught (i.e., used as a dependent variable) or being used as an independent variable to modify another behavior. This caused some issues with discriminating between the articles due to the way the studies were sometimes described in the title and abstract. This led to some articles being removed after having initially passed the initial screening. One example of this was an article by Wu et al. (2017) which evaluated the effects of a cross-circuit exercise training program on improving fitness for participants with ASD. While their study did involve exercise, the participants were not assessed on their learning of the exercise but rather the results of the exercise on their physical health. Another important point that arises is the fact that you cannot use an exercise as an independent variable unless your participants already have the exercise mastered in their repertoire. For individuals with autism this may mean that in many cases, the exercise must be taught prior to the intervention. It is interesting to note that over 300 articles were removed from the final analysis due to having used exercise as an independent variable to modify other behavior or increase health. It is unknown if exercise procedures had to be taught as a prerequisite or were already in the repertoires of participants.

Another barrier to the current systematic review was the use of treatment packages instead of isolated treatment strategies. The included studies were all clinically useful and produced promising results, but due to their varying procedures and use of treatment packages, I was unable to isolate which specific aspects of the interventions were resulting in improvements. All the included studies used treatment packages that featured combinations of various strategies

including prompting, reinforcement, modeling, and other technological applications used in conjunction with each other. Because of this, it is difficult to know which aspect of the treatment package was most effective and which aspects were unnecessary to the conclusions reached.

Limitations and Future Research

This study was not without limitations, a large limitation of this research was the potential of missed articles in the literature review as I focused on articles in English, which could have limited the results as well as the conclusions reached from these data. The review was done by myself alone, which could have led to missed articles that may have potentially been included in this review. While this is a possibility, IOA data were collected, which returned 94% accuracy on final inclusion criteria for 20% of articles included in the review. Some of the articles that passed through the initial search were removed during a second analysis due to reassessment of their meeting of inclusion criteria. Another potential limitation of this review was that exercise was not operationally defined prior to applying the inclusion/exclusion criteria. Again, however, 94% IOA agreement data taken on a 20% sample of studies indicated that this lack of operational definition might not have resulted in confusion. Another potential limitation of this research, as previously mentioned, was the difficulty in determining whether exercise was being taught or being used as an independent variable for some of the articles assessed. The way some of the article abstracts were written and described caused difficulty in identifying whether exercise was being taught to the participants or if the research was just conducted on their existing exercise repertoires. This caused some issues with discrimination of articles that did not teach but rather assessed the effects of existing exercise skills on health or other behavior.

Future directions for this area of research could include more replication of these studies to attempt to develop a more solid empirical base for assessment. While the research was

promising, procedures across studies varied greatly from one another in their delivery. Another possible future direction could include studies that combine multiple parts of the included studies as while these articles had promising results, the influence of all of these factors; modeling, technological assistance, and reinforcement/prompting could lead to even stronger results that continue to advance the literature on exercise interventions for individuals with ASD. Another potential future direction could include examining ways to increase motivation for exercise in autistic individuals. A study by Obrusnikova and Miccinello (2012) reported that according to parents consulted, the biggest barriers for children with ASD included a lack of motivation to engage in physical activities. Pan and Frey (2005) also reported that time spent in sedentary activities was negatively correlated with physical activity among children with ASD. Future studies could look at ways to increase motivation to participate in these activities possibly using goal setting, or access to preferred reinforcers. Overall, I think that information obtained from the current review indicates that researchers should further explore the effects of either live or video modeling in combination with the use of technological applications on the teaching of exercise skills to individuals with autism. Of course, basic principles of reinforcement and prompting would also be required to promote behavior change. A greater emphasis should also be placed on studying maintenance and generalization of learned exercise skills. This would help to make interventions more practical for regular use after interventions conclude and increase the beneficial effects of exercise in the long term.

Figure 1

Initial Search Prisma Chart

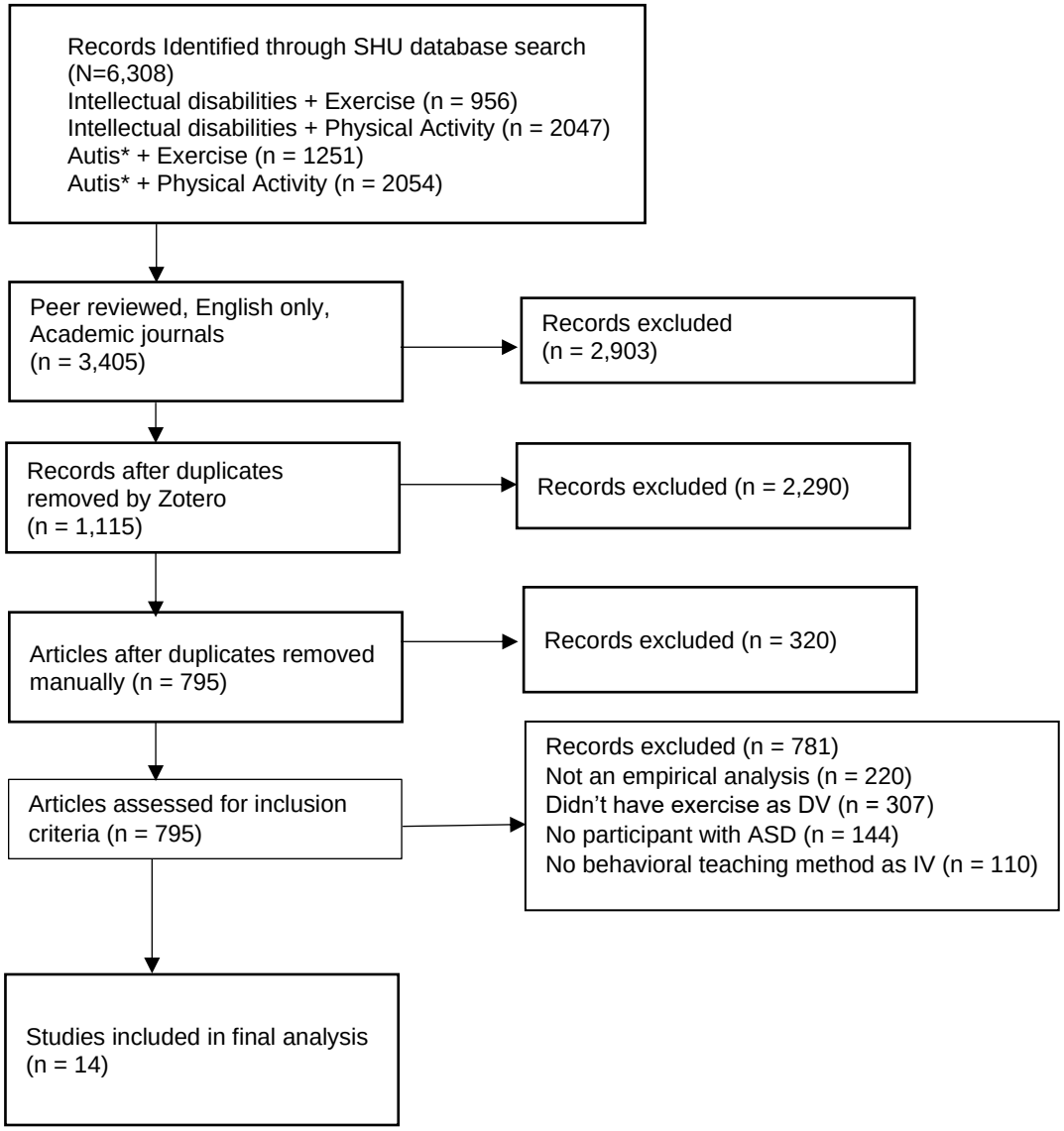

Table 1

Quality assessment of included articles: Primary Indicators

Study	Participant Characteristics	Independent Variable	Dependent Variable	Baseline	Visual Analysis	Exp Control
Arslan et al., (2022)	H	H	H	H	H	H
Bassette et al., (2018)	H	H	H	H	H	H
Bassette et al., (2021)	H	H	H	H	H	H
Becerra et al., (2021)	H	H	H	H	H	H
Dieringer et al., (2017)	H	H	H	H	H	H
Fjellstrom et al., (2022)	H	H	H	A	H	A
Goldman et al., (2022)	H	H	H	H	H	H
Kurt et al., (2018)	H	H	H	H	H	H
Park et al., (2020)	H	H	H	H	H	H
Rotta et al., (2022)	H	H	H	H	H	H
Savage et al., (2018)	H	H	H	H	H	H
Savage et al., (2022)	H	H	H	H	H	A
Todd et al., (2019)	H	H	H	H	H	H
Yarimkawa et al., (2022)	H	H	H	H	H	H

Note. H High; A Acceptable; U Unacceptable

Table 2

Quality assessment of included articles: Secondary Indicators

Study	IOA	Kappa	Blind raters	Fidelity	Gen/Maint	Social Validity	Overall
Arslan et al., (2022)	N	N	N	N	N	Y	Adequate
Bassette et al., (2018)	Y	N	N	Y	Y	Y	Strong
Bassette et al., (2021)	Y	N	N	Y	Y	Y	Strong
Becerra et al., (2021)	Y	N	N	Y	Y	Y	Strong
Dieringer et al., (2017)	Y	N	N	Y	Y	Y	Strong
Fjellstrom et al., (2022)	N	N	N	N	N	Y	Adequate
Goldman et al., (2022)	Y	N	N	Y	Y	Y	Strong
Kurt et al., (2018)	Y	N	N	N	N	Y	Adequate
Park et al., (2020)	Y	N	N	Y	Y	Y	Strong
Rotta et al., (2022)	Y	N	N	N	Y	Y	Adequate
Savage et al., (2018)	Y	N	Y	Y	Y	Y	Strong
Savage et al., (2022)	N	N	Y	Y	N	Y	Strong
Todd et al., (2019)	N	N	N	N	N	Y	Adequate
Yarimkawa et al., (2022)	N	N	N	N	N	Y	Adequate

Note. Gen/Maint. *Generalization/Maintenance*. Y *Yes, reported.* N *Not reported.*

Table 3

Qualitative summary of included studies

Study	Teaching Method	Target Behavior	Participant Characteristics	Effectiveness based on results	Limitations	IOA data	Generalization	Maintenance
Arslan, E. et al. (2022)	Most to least prompting of a 12-week exercise program	Running speed and agility, balance, standing long jump, reaction times, handgrip strength, and flexibility	14 Males with autism 14 Males Diagnosis of ASD	30% greater development with respect to balance, standing long jump, auditory reaction time, and handgrip strength	The cognitive abilities of participants were not measured.	N/A	N/A	N/A
Bassette et al. (2018)	Exercise Buddy app Prompting Reinforcement Video Modeling	Percentage of steps of each exercise performed correctly.	3 Participants Ages 14-22 IQ of 55 or higher Diagnosis of ASD	3 of 3 participants increased ability to perform PA skills independently across phases.	Did not use fading of components to determine which are critical.	33%–45% of sessions Average agreement was 98.1%	N/A	N/A
Bassette et al. (2021)	Commercial video-models Custom-made video models	Participants' ability to perform exercises independently in a community site and Steps performed correctly	3 participants Ages 14-22 Diagnosis of ASD	2 of 3 performed more independently with custom video models 1 of 3 performed more independently with commercial video models	App would only permit videos less than 30s Videos were shortened which may have limited specificity	Treatment fidelity was 100% for all participants across all phases.	Five generalization sessions occurred 1 week after the best treatment	N/A
Becerra et al. (2021)	Photographic activity schedule	Physical activity	3 Participants 1 Male 2 Female Aged 4 Diagnosed with ASD	3 of 3 participants met activity schedule teaching mastery criterion and demonstrated high levels of MVPA	2 participants sessions were typically 5 min or less, 1 participants teaching sessions lasted longer than 5 min	33% of sessions 92%, 91%, and 94%	Occurred after the initial schedule probe and after the no-schedule probe. Session was terminated after 5 min or the completion of the activity schedule.	Two weeks after final generalization session. Maintenance session ended after the participant completed the activity schedule.
Dieringer et al. (2017)	Instruction with music Verbal prompting Modeling	Gross Motor Task Completion (GMTC) in physical activity	Five Participants Diagnosis of ASD.	5 of 5 participants showed improvement during modeling and prompting	Receptive language skills and cognitive abilities were not assessed. Previous	25% of sessions 88% to 99% in baseline, 88% to 96% in MI, 83% to 97% in MM, and 96% to	Conducted every three to four sessions. Students listened to a similar, but	N/A

				Change was modest.	programming for GM imitation is unknown. One-on-one sessions not as generalizable Verbal prompts and modeling were not evaluated in isolation	100% in generalization.	novel music track. 0 of 5 participants demonstrated generalization to a novel song.	
Fjellstrom et al. (2022)	a web-based training program called "MyMOWO"	Physical activity	28 Participants 48% female Average age 36.4 ± 9.56 years	The intensity of the PA level increased and a decrease in fat mass	COVID-19 may have influenced participation. Study did not control for food/drink intake	N/A	N/A	N/A
Goldman et al. (2022)	Token-based intervention	Physical activity engagement	4 participants 4 males Age 8 Diagnosis of ASD	2 of 4 participants increased physical activity.	Limited number of physical activity options	IOA averaged 92%, 93%, 95%, and 90%	N/A	N/A
Kurt et al. (2018)	most to least prompting method	Steps performed correctly of dynamic stretching exercise.	4 participants All women 34-37 years old	Most to least prompting method was effective in 4 of 4 participants.	N/A	N/A	Pre-test and post-test sessions on generalization were conducted	All assessed participant maintained performance Two weeks after the end of the program
Park et al., (2020)	Peer-Delivered Simultaneous Prompting Procedure	Chained task of shooting a basketball Nontargeted content learning fine motor, gross motor, and movement knowledge	4 participants 2 female 2 male 12-14 years old	all participants improving in shooting a basketball but only one of four improving in nontargeted content learning.	Maintenance limited by school year Failure to conduct probe sessions for generalization No random assignment of tutors (only students without ID)	32% of sessions mean IOA was 91.4%	N/A	
Rotta et al. (2022)	Individualized daily choice Modeling	Number of steps taken Calories burned	6 Participants 3 Male 3 Female	6 of 6 participants increased	Did not determine whether	20% of sessions 90% accuracy	N/A	1 week after sessions

	Token reinforcement		Ages 19–24	number of steps and calories burned	participants increased their strength or aerobic capacity			completed with 2 participants
Savage et al. (2018)	Praise statements: In-person and Through technology	Engagement in physical activity	3 participants 3 Male Ages 20-22	3 of 3 participants increased laps taken	Devices used to measure heart rate were not calibrated.	33% of sessions 96.3% accuracy 98.1% accuracy 96.3% accuracy	3 sessions, same procedure as thinning phase	N/A
Savage et al. (2022)	Supported Self-Management and Fitbit Technology	Increasing Physical Activity	40 participants Ages 18-57 Randomly assigned to a control or intervention group. 70.6% male	Participants in the Step It Up program had significantly higher average weekly step counts and lost more weight than the control group	Sample size Lack of standardized measures for confirming ASD diagnoses Frequency of contact between coaches and participants was not measured	Average procedural fidelity was 90.9%	N/A	N/A
Todd et al. (2019)	Peer mentoring	Increased physical activity and fitness	16 participants 3 Females 13 Males Ages 18-28 Diagnosis of ASD or Aspergers	30% showed significant improvement in cardiorespiratory fitness. 25% in upper body muscular endurance	Small sample size No control group No way to know effort level of participants	N/A	N/A	N/A
Yarimkawa et al. (2022)	WhatsApp-delivered physical activities	Physical fitness levels	42 participants 21 in experimental (8 girls and 13 boys) 21 in control 6 girls and 15 boys Mean age 5.22 Diagnosis of ASD	Significant increase in physical activity level	Small sample size No follow up test	N/A	N/A	N/A

References

American Academy of Pediatrics. (2019). Autism spectrum disorder: Diagnosis. *Pediatrics, 145*(1), e20193447. https://doi.org/10.1542/peds.2019-3447

American College of Sports Medicine. (2018). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Wolters Kluwer.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.).

Arslan, E., Ince, G., & Akyüz, M. (2022). Effects of a 12-week structured circuit exercise program on physical fitness levels of children with autism spectrum condition and typically developing children. *International Journal of Developmental Disabilities*, 68(4), 500–510. https://doi.org/10.1080/20473869.2020.1819943

Attwood, T. (2003). Frameworks for behavioral interventions. *Child and Adolescent Psychiatric Clinics of North America, 12*(1), 65-86. doi: 10.1016/s1056-4993(02)00092-0.

Baer, D. M., Wolf, M. M., & Risley, T. R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis, 1*(1), 91-97. https://doi.org/10.1901/jaba.1968.1-91

Bandini, L. G., Anderson, S. E., Curtin, C., Cermak, S., Evans, E. W., Scampini, R., Maslin, M., Must, A. (2010). Food selectivity in children with autism spectrum disorders and typically developing children. *Journal of Pediatrics, 157*(2), 259-264. doi: 10.1016/j.jpeds.2010.02.013

Baranek, G. T. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders, 32*(5), 397-422.

Bassette, L. A., Tabak, R. G., Fox, E. H., & Ali, M. K. (2018). The impact of interventions that integrate accelerometers on physical activity and weight loss: a systematic review. *Annals of Behavioral Medicine, 52*(2), 157-170.

Bassette, L. (2021, December). A Comparison of App-Based Video-Modeling Interventions to Teach Physical Activity Skills to People With Autism in a Community Setting. *Journal of Special Education Technology*, *36(4*), 227-239. ISSN: 0162-6434.

Becerra, L. A. (1), Higbee, T. S. (1), Pellegrino, A. J. (1), Hobson, K. (1), & Vieira, M. C. (2). (2021). The effect of photographic activity schedules on moderate-to-vigorous physical activity in children with autism spectrum disorder. *Journal of Applied Behavior Analysis,* 54(2), 744-759. https://doi.org/10.1002/jaba.796

Bicer, A. H., & Alsaffar, A. A. (2013). Body mass index, dietary intake and feeding problems of Turkish children with autism spectrum disorder (ASD). *Research in Developmental Disabilities, 34*(11), 3978–3987. https://doi.org/10.1016/j.ridd.2013.08.024

Bishop, J., Nichols, C., McIntire, B., & Block, M. E. (2018). Using the ICF Model to Increase Physical Activity of Young Adults with ASD Residing in Group Homes. *Palaestra, 32*(4), 47.

Bodde, A. E., Helsel, B. C., Hastert, M., Suire, K. B., Washburn, R. A., Donnelly, J. E., & Ptomey, L. T. (2022). The prevalence of obesity and lifestyle behaviors of parents of youth with intellectual and developmental disabilities. *Disability and Health Journal*. https://doi.org/10.1016/j.dhjo.2022.101430

Butler, L. K., & Tager-Flusberg, H. (2023). Fine motor skill and expressive language in minimally verbal and verbal school-aged autistic children. *Autism Research, 16*(3), 630-641. https://doi.org/10.1002/aur.2883

Casey, M., Ting Liu, Breslin, & ElGarhy, S. (2017). Motor Skill Assessment in Autism Spectrum Disorder: A Case Study. *Physical Educator, 74*(2), 239–254.

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics, 31*(1), 219-230. https://doi.org/10.1016/j.jhealeco.2011.10.003

Cooper, J. O., Heron, T. E., & Heward, W. L. (2020). *Applied behavior analysis* (3rd ed.). Pearson.

Curtin, M., Fossey, E., & Applegate, K. (2010). Evaluation of a peer-led education program for consumers with mental illness. *Journal of Mental Health, 19*(6), 526-535.

Dawson, G., Rogers, S., Munson, J., Smith, M., Winter, J., Greenson, J., & Varley, J. (2010). Randomized, controlled trial of an intervention for toddlers with autism: The Early Start Denver Model. *Pediatrics, 125*(1), e17-e23. https://doi.org/10.1542/peds.2009-0958

DeMeyer, M. K., Alpern, G. D., Barton, S., DeMyer, W. E., Churchill, D. W., Hingtgen, J. N., Bryson, C. Q., Pontius, W., & Kimberlin, C. (1979). Imitation in autistic, early schizophrenic, and non-psychotic subnormal children. *Journal of Autism and Childhood Schizophrenia, 2*(3), 264–287. https://doi.org/10.1007/BF01537618

Dieringer, S. T., Zoder-Martell, K. A., Dufrene, B. A., Zoder-Martell, K., Porretta, D. L., Bricker, A., & Kabazie, J. (2017). Increasing Physical Activity in Children with Autism

through Music, Prompting, and Modeling. *Psychology in the Schools*, 54(4), 421. https://doi.org/10.1002/pits.22003

Dodson, L. C., & Mullens, W. R. (1969). Some effects of jogging on psychiatric hospital patients. *American Corrective Therapy Journal, 23*(5), 130-134.

Donnelly, J. E., Blair, S. N., Jakicic, J. M., Manore, M. M., Rankin, J. W., & Smith, B. K. (2009). American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and Science in Sports and Exercise, 41*(2), 459-471.

Dwyer, M., & McQuillan, S. (2018). The role of parental engagement in student achievement: Evidence from rural and urban middle schools. *Journal of Education for Students Placed at Risk (JESPAR), 23*(3), 130-144.

Eaves, L. C., Ho, H. H. (2008). Young adult outcome of autism spectrum disorders. *Journal of Autism and Developmental Disorders, 38*(4), 739-747. doi: 10.1007/s10803-007-0441-x.

Elias, R. Z., Weiss, D., & Burt, T. (2019). Ambiguous loss: A review of literature and new directions for research. *Family Process, 58*(2), 377-392.

Fjellstrom, S., Hansen, E., Hölttä, J., Nordström, A., Lund Ohlsson, M., & Zingmark, M. (2022). Web-based training intervention to increase physical activity level and improve health for adults with intellectual disability. *Journal of Intellectual Disability Research*, 66(12), 967-977. https://doi.org/10.1111/jir.12984

Foley, J. T., Galloway, J. C., & Gengoux, G. W. (2018). The role of motor activity in understanding autism spectrum disorder. *Developmental Medicine & Child Neurology, 60*(8), 773-778.

Fournier, K. A., Hass, C. J., Naik, S. K., Lodha, N., & Cauraugh, J. H. (2010). Motor coordination in autism spectrum disorders: A synthesis and meta-analysis. *Journal of Autism and Developmental Disorders, 40*(10), 1227-1240.

Gabler-Halle D, Halle JW, Chung YB. (1993). The effects of aerobic exercise on psychological and behavioral variables of individuals with developmental disabilities: A critical review. *Research in Developmental Disabilities, 14*(5), 359-386. https://doi.org/10.1016/0891-4222(93)90009-9

Ginsburg, K. R. (2007). The importance of play in promoting healthy child development and maintaining strong parent-child bonds. *Pediatrics, 119*(1), 182-191. doi: 10.1542/peds.2006-2697

Goldman, K. J., & DeLeon, I. G. (2022). Increasing Selection of and Engagement in Physical Activity in Children with Autism Spectrum Disorder. *Journal of Applied Behavior Analysis*, 55(4), 1083–1108. https://doi.org/10.1002/jaba.929

Gual, E., Sánchez-Raya, M. A., Elvira, J. A. M., Salas, B. L., & Cívico, F. A. (2015). Early intervention in autism spectrum disorders (ASD). *Psicologia Educativa, 21*(1), 55-63–63. https://doi.org/10.1016/j.pse.2014.04.001

Healy, O., Dacosta, M., Murphy, N., McCormack, J., & Lydon, H. (2017). A systematic review of the use of behavior analytic interventions for teaching new skills to individuals with

autism spectrum disorders. *Review Journal of Autism and Developmental Disorders, 4*(1), 1-14. doi: 10.1007/s40489-016-0095-1

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 40.

Katz, L. Y., Weaver, J. C., & Sciaraffa, N. (2010). Exercise as a promising intervention for behavior in autism spectrum disorders: A review of the literature. *Current Opinion in Psychiatry, 23*(6), 565-570. doi: 10.1097/YCO.0b013e32833e61b7

Klein U, Nowak A. (1999). Characteristics of patients with autistic disorder (AD) presenting for dental treatment: A survey and chart review. *Special Care in Dentistry, 19*(5), 200-207. doi: 10.1111/j.1754-4505.1999.tb01386.x

Kurt, Ö., & Çuhadar, S. (2018). Effects of Most to Least Prompting Procedure on Teaching Exercise for Adults with Intellectual Disabilities. Journal of Education and Training Studies, 6, 1–14.

Lang, R., Koegel, L. K., Ashbaugh, K., Regester, A., Ence, W., & Smith, W. (2010). Physical exercise and individuals with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 4*(4), 565-576.

Levick, Y. S., & Quinn, N. (2019). The benefits of physical activity for youth with autism spectrum disorders: A systematic review. *Review Journal of Autism and Developmental Disorders, 6*(2), 172-182. doi: 10.1007/s40489-018-0152-3

Lienhard, K. L., & Staiano, A. E. (2016). The association between physical activity and ADHD in children and adolescents: A systematic review. *Journal of Attention Disorders, 20*(10), 1-14. doi: 10.1177/1087054715627484

Lord, C., Elsabbagh, M., Baird, G., & Veenstra-Vanderweele, J. (2018). Autism spectrum disorder. *The Lancet, 392*(10146), 508-520. https://doi.org/10.1016/S0140-6736(18)31129-2

Lord, C., Rutter, M., DiLavore, P., & Risi, S. (2001). Autism Diagnostic Observation Schedule (ADOS). Western Psychological Services.

Lovaas, O. I. (1987). Behavioral treatment and normal educational and intellectual functioning in young autistic children. *Journal of Consulting and Clinical Psychology, 55*(1), 3-9.

Mandy, W., Charman, T., & Skuse, D. (2012). Testing the construct validity of proposed criteria for DSM-5 autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 51*(1), 41-50. doi: 10.1016/j.jaac.2011.10.018

Matson, J. L., & Kozlowski, A. M. (2011). The increasing prevalence of autism spectrum disorders: Autism Spectrum Disorders: A Transactional Developmental Perspective. *Research in Autism Spectrum Disorders, 5*(1), 418-425. doi: 10.1016/j.rasd.2010.06.005.

Ming, X., Patel, R., Kang, V., Chokroverty, S., & Julu, P. O. (2016). Respiratory and autonomic dysfunction in children with autism spectrum disorders. *Brain and Development, 38*(2), 225-232. https://doi.org/10.1016/j.braindev.2015.07.003

Miramontez, S. K. H., & Schwartz, I. S. (2016). The Effects of Physical Activity on the On-Task Behavior of Young Children with Autism Spectrum Disorders. *International Electronic Journal of Elementary Education, 9*(2), 405–418.

Must, A., Phillips, S., Curtin, C., Bandini, L. (2015) Barriers to Physical Activity in Children With Autism Spectrum Disorders: Relationship to Physical Activity and Screen Time. *J Phys Act Health. 2015* Apr;12(4):529-34. doi: 10.1123/jpah.2013-0271. Epub 2015 Apr 28. PMID: 25920014; PMCID: PMC4490003.

Ng, M., Fleming, T., Robinson, M. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet.* 2014 Aug 30;384(9945):766-81. doi: 10.1016/S0140-6736(14)60460-8.

Obrusnikova I, Miccinello DL. (2012). Parent perceptions of factors influencing after-school physical activity of children with autism spectrum disorders. *Adapted Physical Activity Quarterly, 29*(1), 63-80. doi: 10.1123/apaq.29.1.63

Obrusnikova, I., & Cavalier, A. R. (2011). Perceived barriers and facilitators of participation in after-school physical activity by children with autism spectrum disorders. *Journal of Developmental and Physical Disabilities, 23*(3), 195-211.

Pan, C. (2010). Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. *Autism,* 14(1), 9-28.

Pan, Frey, & Bar-Or (2005). Concordance of Physical Activity Among Parents and Youth with Physical Disabilities. *J Dev Phys Disabil 17*, 395–407 (2005). https://doi.org/10.1007/s10882-005-6622-7

Park, G., Collins, B. C., & Lo, Y. (2021). Teaching a Physical Activity to Students with Mild to Moderate Intellectual Disability Using a Peer-Delivered Simultaneous Prompting Procedure: A Single-Case Experimental Design Study. *Journal of Behavioral Education*, 30(3), 378–396. https://doi.org/10.1007/s10864-020-09373-7

Reichow, B. (2011). Evidence-based practices for children with autism: Contributions for single-case design research. *Journal of Autism and Developmental Disorders*, *41*(5), 607-619. doi: 10.1007/s10803-011-1339-9

Rogers, S. J., & Vismara, L. A. (2008). Evidence-based comprehensive treatments for early autism. *Journal of Clinical Child & Adolescent Psychology, 37*(1), 8-38. https://doi.org/10.1207/s15374424jccp3701_2

Rosenkilde, M., Nordby, P., Nielsen, L. B., Stallknecht, B., & Helge, J. W. (2017). Fat oxidation at rest predicts peak fat oxidation during exercise and metabolic phenotype in overweight men. *International Journal of Obesity, 41*(2), 221-227. doi: 10.1038/ijo.2016.212

Rotta, K., Rangler, K., Ragotzy, S., & Poling, A. (2022). Increasing Physical Activity in Young Adults with an Intellectual Disability via a Classroom-wide Treatment Package. *Behavior Analysis in Practice*, 15(4), 1314–1325. https://doi.org/10.1007/s40617-022-00691-y.

Sandt, D. D., & Frey, G. C. (2015). Physical activity considerations for the student with autism spectrum disorder. *Journal of Physical Education, Recreation & Dance, 86*(2), 44-49.

Savage, M. N., Taber-Doughty, T., Brodhead, M. T., & Bouck, E. C. (2018). Increasing physical activity for adults with autism spectrum disorder: Comparing in-person and technology delivered praise. *Research in Developmental Disabilities*, 73, 115–125. https://doi.org/10.1016/j.ridd.2017.12.019

Savage, M. N. (1), Tomaszewski, B. T. (2), & Hume, K. A. (2) (2022). Step It Up: Increasing Physical Activity for Adults With Autism Spectrum Disorder and Intellectual Disability Using Supported Self-Management and Fitbit Technology. *Focus on Autism and Other Developmental Disabilities,* 37(3), 146-157. https://doi.org/10.1177/10883576211073700

Shanker, S. G., & Banda, D. R. (2016). Exercise as an intervention for children with autism spectrum disorder: A systematic review. *Autism Research and Treatment, 2016*, 1-12.

Sharp WG, Volkert VM, Scahill L, McCracken CE, McElhanon BO. (2015). A systematic review and meta-analysis of intensive multidisciplinary intervention for pediatric feeding disorders: How standard is the standard of care? *Journal of Autism and Developmental Disorders, 45*(7), 2517-2538. doi: 10.1007/s10803-015-2407-8.

Skinner, B. F. (1953). Science and human behavior. Macmillan.

Smith, T., & Iadarola, S. (2015). Evidence base update for Autism Spectrum Disorder. *Journal of Clinical Child & Adolescent Psychology, 44*(6), 897-922. https://doi.org/10.1080/15374416.2015.1077448

Sowa, M., Meulenbroek, R., & Whitney, R. (2017). Motivating children with autism spectrum disorder to engage in physical activity: A review of theory and research. *Journal of Autism and Developmental Disorders, 47*(12), 3765-3779. doi: 10.1007/s10803-016-2993-8

Srinivasan, S. M., Pescatello, L. S., & Bhat, A. N. (2014). Current perspectives on physical activity and exercise recommendations for children and adolescents with autism spectrum disorders. *Physical Therapy and Rehabilitation, 1*(1), 17-23.

Thorndike, E. L. (1898). Animal intelligence: An experimental study of the associative processes in animals. *Psychological Review, 2*(1), 1-22. https://doi.org/10.1037/h0067814

Tyler, K., MacDonald, M., & Menear, K. (2014). Physical activity and physical fitness of adults with autism spectrum disorders. *Autism Research and Treatment, 2014*, 1-8.

Todd, T., Bougher, S.C., Miodrag, N., & Zambom, A.Z.(2019). A Peer Mentored Physical Activity Intervention: An Emerging Practice for Autistic College Students. *Autism in Adulthood*, 1, 232–237.

Vogan, V. M., Mulloy, A., & Frazier, T. W. (2018). Social motivation in individuals with autism spectrum disorder: Implications for physical activity participation. *Review Journal of Autism and Developmental Disorders, 5*(3), 300-310. doi: 10.1007/s40489-018-0135-5

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review, 20*(2), 158-177. https://doi.org/10.1037/h0074428

Wong, C., Odom, S. L., Hume, K. A., Cox, A. W., Fettig, A., Kucharczyk, S., … Schultz, T. R. (2015). Evidence-based practices for children, youth, and young adults with Autism Spectrum Disorder: A comprehensive review. *Journal of Autism and Developmental Disorders, 45*(7), 1951-1966. https://doi.org/10.1007/s10803-014-2351-z

World Health Organization. (2021). Obesity and overweight: Key facts. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Wu, W.-L., Yang, Y.-F., Chu, I.-H., Hsu, H.-T., Tsai, F.-H., & Liang, J.-M. (2017). Effectiveness of a cross-circuit exercise training program in improving the fitness of overweight or obese adolescents with intellectual disability enrolled in special education

schools. *Research in Developmental Disabilities, 60*, 83–95. https://doi.org/10.1016/j.ridd.2016.11.005

Yarımkaya, E., Esentürk, O. K., İlhan, E. L., & Karasu, N. (2022). A WhatsApp-delivered intervention to promote physical activity in young children with autism spectrum disorder. *International Journal of Developmental Disabilities*, 68(5), 732–743. https://doi.org/10.1080/20473869.2021.1887436

Zazpe, I, Marí-Bauset, S., Llopis-González, A., Marí-Sanchis, A., & Morales Suárez-Varela, M. (2017). Comparison of nutritional status between children with autism spectrum disorder and typically developing children in the Mediterranean Region (Valencia, Spain). *Autism: The International Journal of Research and Practice, 21*(3), 310–322. https://doi.org/10.1177/1362361316636976

Zhao, M., and Chen, S. (2018). The effects of structured physical activity program on social interaction and communication for children with autism. *Biomed Res. Int. 2018*, 1825046. doi: 10.1155/2018/1825046

Zimmer MH, Hart LC, Manning-Courtney P, Murray DS, Bing NM, Summer S. (2012). Food variety as a predictor of nutritional status among children with autism. *Journal of Autism and Developmental Disorders, 42*(4), 549-556. doi: 10.1007/s10803-011-1268-z.

Zurlo, F., Larson, K., Bogardus, C., & Ravussin, E. (1990). Skeletal muscle metabolism is a major determinant of resting energy expenditure. *Journal of Clinical Investigation, 86*(5), 1423-1427. https://doi.org/10.1172/JCI114857