



DEVELOPMENTAL, PSYCHOLOGICAL, AND SOCIAL EFFECTS OF PHYSICAL ACTIVITY ON CHILDREN WITH AUTISM

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Abstract:

The current research explores the developmental, psychological, and social influence of physical activity on children who suffer from autism spectrum disorder (ASD). Autism is a developmental disability that involves the lack of social and communicational skills, repetition of behaviors and movements, as well as challenges with motor development. According to studies, people with autism engage in less physical activity which poses the threat of becoming overweight. Nonetheless, planned physical activities such as swimming, horse riding therapy, martial arts, and gymnastics positively influence motor development, decrease stereotypical behaviors, develop cognitive abilities and promote social interaction. Overall, physical activity is one of the key intervention methods that help develop individuals with autism.

Keywords: Autism, physical activity, motor development, social interaction

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that develops in early childhood and is characterized by significant deficits in social communication and interactions, as well as restrictive and repetitive patterns of behavior (American Psychiatric Association, 2022). The term "spectrum" implies that there is no unified clinical picture of autism because considerable differences exist among patients in terms of severity of symptoms, cognitive abilities, speech, adaptation and life skills (Lord *et al.*, 2020). Thus, there are different manifestations of autism spectrum disorder ranging from people with mild needs to people who have a serious need for assistance (Lord *et al.*, 2020).

It should be noted that in recent years, the prevalence rate of autism has increased significantly in the world. According to recently released data by the U.S. Centers for

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Disease Control and Prevention (CDC), about one out of 31 children suffers from ASD (Maenner, 2023). As it is said, the increase in the number of cases is related not only to an actual increase in the prevalence rate but also to changes in diagnostic criteria, early diagnosis, better access to medical care and increased awareness (Lord *et al.*, 2020; İnce, 2017). Turkey has also experienced an increase in the number of people with autism using special education services, which shows the need to reconsider the approaches in education, medicine, and sports (Arslan, 2019). It is not just social communication problems that characterize Autism Spectrum Disorder. Motor developmental difficulties have been found to be another core feature of ASD. Children with autism tend to be underdeveloped in terms of gross and fine motor skills, balance, posture control, agility, motor planning, movement coordination, among others (Fournier *et al.*, 2010; Bremer & Lloyd, 2016). The mentioned motor difficulties hinder not only sport achievements, but also engagement in everyday activities, independent locomotion, and social interactions (Aydın & Sarol, 2016). Moreover, people with ASD are known to have low physical activity levels in comparison with the rest of the population. The reason for that can be attributed to various factors like too much time spent in front of a computer screen, fear of social situations, sensory sensitivities, narrow interests, safety of family members, and lack of appropriate sport programs (Aksoy, 2020; Jones *et al.*, 2017). The lack of physical activity further contributes to various other health problems, such as obesity, increased risk of cardiovascular disease, musculoskeletal disorders, and mental conditions (Healy *et al.*, 2018). According to the recommendations by the World Health Organization (2020), all children and adolescents should undertake at least 60 minutes of physical activity each day. However, recent studies reveal that many autistic children do not meet this requirement (Tyler *et al.*, 2014).

Consequently, physical activities cannot be viewed simply as recreational, but also as a health intervention tool for supporting the comprehensive development of individuals with autism. Research conducted in sports sciences within the last two decades shows that benefits from regular physical activity in autistic people go far beyond mere physical fitness. Aerobic exercises, coordination training, swimming, athletics, martial arts, cycling, dancing and recreation therapies have been shown to improve motor skills, increase attention span, decrease stereotyped behaviors, manage problematic behaviors, and help develop social interactions (Taner, 2020; Lang *et al.*, 2010; Sowa & Meulenbroek, 2012; Healy *et al.*, 2018). Exercise, in particular, has been shown to have positive impacts on executive functions, self-regulation, and cognitive function. The mental health benefits of physical activity are receiving more attention too. An increase in the production of neurochemicals, including endorphins, serotonin, and dopamine, when exercising has been found to have mood-enhancing properties, reduce anxiety and promote behavioral control (Ratey & Hagerman, 2008). Several empirical studies have indicated that exercise programs for people with autism can help reduce their stress levels, improve their attention, and enhance engagement in activities of daily living (Bremer *et al.*, 2016). Also, physical activity has been shown to contribute to better sleep quality, higher satisfaction with life, and improved self-efficacy (Kaya *et al.*, 2020; Healy

et al., 2018). One of the important benefits offered by sports is that it helps in social development. Participation in team sports, exercises, and physical activities in general enables the development of social skills such as sharing, taking turns, following the rules, maintaining eye contact, peer interaction, and cooperation in a natural setting (Pan, 2010; Doğan *et al.*, 2025). Sports, especially those that are inclusive in nature, allow autistic people to interact with their normally developing peers in an environment where they can learn to be socially acceptable (Shields & Synnot, 2016). However, important obstacles related to the engagement of autistic people in sports remain. The lack of skilled coaches, absence of individual sports programs, unavailability of sports facilities, insufficient information possessed by parents, and financial difficulties can be mentioned as such barriers (Obrusnikova & Miccinello, 2012). In addition, some people can experience difficulties related to sensory sensitivities (for example, loud noise, crowded spaces, or bright lighting). Therefore, sports programs have to be individualized based on the developmental profile of each participant, use visual aids, rely on structured learning strategies, and use an interdisciplinary approach if needed. Systematic reviews and meta-analyses conducted recently demonstrate the medium to large benefits associated with the application of physical activity intervention for individuals with autism in terms of motor skills, physical fitness, social communication, and quality of life (Bremer *et al.*, 2016; Healy *et al.*, 2018).

However, there remains a need for more robust scientific proof because much of the research that has been done thus far relies on small sample sizes, intervention time frames, and inconsistent forms of exercise. More specifically, more longitudinal randomized control trials and more research in different age ranges and different types of sports would help immensely to create scientifically backed exercise guidelines for people with autism.

2. Main Body and Conclusion

2.1 Main Characteristics of Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopment disorder that develops during early childhood and influences the social communication, social interactions, and behavior of the affected individuals. The criteria for diagnosing ASD according to DSM-5-TR are stated by the American Psychiatric Association and are associated with two main characteristics: (1) persistent deficits in social communication and social interaction, and (2) restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2022).

Nevertheless, there is evidence suggesting that such aspects as motor developmental problems, sensory processing differences, deficits in physical fitness, and poor health-related quality of life have a significant impact on the lives of people with autism (Balci *et al.*, 2024; Lord *et al.*, 2020; Fournier *et al.*, 2010). "Spectrum" in the name of the disease refers to the variability of symptom manifestation, their intensity, and the functioning of the individual affected by autism. On the one hand, some people can cope

quite independently, while on the other hand, the need for intensive lifelong support is required. Additionally, different levels of language development, cognition, motor skills, and social adaptation are evident (Lord *et al.*, 2020). Such heterogeneity requires an individual approach to the education process, rehabilitation, and physical exercises.

2.2 Social Communication and Social Interaction Problems

Another significant feature that marks people with autism is their problems with social communication skills. This type of issue does not include only the ability to speak but also many other complicated skills like reciprocal communication, sharing emotions, interpretation of social signals and interpersonal relationships (APA, 2022). Some of the most visible signs in early childhood include the absence of eye contact, not responding to one's name, poor joint attention and reduced interest in playing with peers (Lord *et al.*, 2020).

Later in life, despite the presence of speech, people may have persistent problems with initiating and sustaining a conversation, body language and facial expression recognition, and understanding of metaphorical language and jokes. This can lead to difficulties in academic life, peer relationships and involvement in sports games (Volkmar & Wiesner, 2017). The fact that the environment of sports involves constant communication with peers and social behavior makes social communication problems an important barrier to sports activity among people with autism. However, well-designed sports programs can help people to develop in these areas significantly (Bremer *et al.*, 2016).

2.3 Restricted and Repetitive Behaviors

The second primary diagnostic domain of autism spectrum disorder (ASD) described by DSM-5-TR includes restricted and repetitive patterns of behavior (APA, 2022). This symptom may vary greatly from one individual to another. Hand-flapping, rocking, spinning, spinning things, sticking to strict routines, inflexibility, and highly restricted, focused interests are among the most frequent examples. These behaviors are viewed by many as attempts by the person to cope with stimuli or to reduce the level of anxiety. Nevertheless, they may become an obstacle in the process of daily functioning and socialization, complicating the process of education and rehabilitation (Lord *et al.*, 2020). A number of studies have found that regular physical exercises, especially moderate-to-vigorous aerobic exercises, help decrease stereotypic behaviors significantly (Lang *et al.*, 2010; Sowa & Meulenbroek, 2012). Besides contributing to the development of a child physically, they play an important role in behavioral regulation.

2.4 Features of Motor Development

While motor development difficulties were not among the criteria for the diagnosis of autism in earlier years, this problem is now considered a common characteristic of autism spectrum disorders. Meta-analysis showed that people with autism exhibited worse motor functions than typically developing individuals in gross motor skills, fine motor

coordination, posture control, balance, agility, ball skills, and motor planning (Fournier *et al.*, 2010).

Problems with motor coordination in childhood can negatively impact basic motor skills like walking, running, going up and down the stairs, jumping, catching, and throwing. Especially because of the praxis deficit, the acquisition of new motor patterns takes much time (Lloyd *et al.*, 2013). Thus, children may have fewer opportunities to be physically active and may be unwilling to engage in games with other kids. Atypical development of balance control is related to problems in the functioning of the vestibular system and cerebellum. This problem affects not only motor skills in sport but also risks of falling and activities of daily living (Fournier *et al.*, 2010). Recently, it was found out that exercises on balance, coordination, and basic movements positively impact motor functions of people with autism (Bremer & Lloyd, 2016).

2.5 Sensory Processing Differences

Many people on the autism spectrum have problems with sensory processing. Even though some people have hypersensitivity to their environment through sounds, lights, touch, or smells, some people can be hyposensitive to the same stimuli (Schaaf & Lane, 2015). These sensory difficulties can create many obstacles for engagement, especially in certain environments like a gym, pool, or team sports.

For example, whistles, arena noise, and bright lights can cause anxiety in some people, and certain touch, sports equipment, and contact can cause extreme discomfort. Therefore, it is recommended to adapt the environment to the sensory needs of an individual, as well as to create exercise programs accordingly (Obrusnikova & Miccinello, 2012).

2.6 Physical Fitness and Health Problems

It has been proven that people with autism have reduced cardiorespiratory endurance, muscular strength, flexibility, and general level of physical fitness compared to their non-autistic counterparts (Healy *et al.*, 2018). The main factors that contribute to this phenomenon are insufficient physical activity, minimal engagement in sports activities, poor motor skills, and a sedentary lifestyle.

Physical inactivity has a negative impact on physical fitness but can also contribute to obesity, hypertension, diabetes, and cardiovascular diseases. More importantly, a lack of physical activity developed since childhood increases the risk of developing such diseases later in life (World Health Organization, 2020). According to a systematic review carried out by Jones *et al.* (2017), the daily physical activity among children with autism is below the recommendations, with significantly high screen time. It is thus paramount to encourage physical activities at an early stage.

2.7 Factors that Influence Sports Participation

Not only are there individual factors that influence sports participation of persons with autism, but there are also family-related, educational, and environmental factors. The

unavailability of trained coaches, lack of available facilities, safety concerns of parents, financial problems, and lack of societal awareness are some of the key factors that limit sports participation (Shields *et al.*, 2012).

It should be mentioned that due to unwillingness to make changes and rigidity, it is difficult for some individuals to adjust to the new sports environment for some individuals. The use of visual support, small groups, structuring of activities, and consideration of individual differences increases sports participation (Bremer *et al.*, 2016).

3. Physical Activity as Part of Autism Therapy

Physical activity is a basic factor of healthy development and one of the most essential activities influencing the physical, psychological, cognitive, and social well-being of an individual. According to WHO (2020), children and adolescents need to spend at least 60 minutes doing moderate-intensity or vigorous physical activity on a daily basis. However, numerous studies have found out that the majority of children and adolescents with ASD fail to meet these requirements (Jones *et al.*, 2017). Such failure may be explained by motor coordination problems, social communication difficulties, sensory issues, restricted interest in various activities, lack of a proper physical activity environment, and parents' safety concerns (Obrusnikova & Miccinello, 2012).

Over the last decade, studies performed in different disciplines (sports sciences, special education, and rehabilitation) have shown that not only does physical activity contribute to the increase of physical fitness of autistic patients, but it also brings significant results in terms of motor skills, cognitive abilities, psychological well-being, social communication skills, and quality of life (Bremer *et al.*, 2016; Healy *et al.*, 2018). Therefore, physical activity is considered one of the evidence-based components of therapy and education of autistic people.

3.1 The Significance of Physical Activity with Regards to Physical Development

The scientific literature indicates that physical fitness levels in individuals with autism are lower in comparison to those of typically developing children (Tyler *et al.*, 2014; Healy *et al.*, 2018). Specifically, problems with muscular strength, aerobic fitness, balance, flexibility, and coordination may impede activities of daily living and independent mobility skills. Cardiovascular efficiency is achieved through aerobic exercises, while muscular strength is developed through resistance training. At the same time, balance and coordination exercises contribute to vestibular development and promote safer movement while performing daily activities (Bremer & Lloyd, 2016).

Finally, it is crucial to mention that low physical activity levels are one of the significant risk factors for obesity among children with autism. According to Bandini *et al.* (2010), the rates of obesity in children with autism are higher than in typical developing children. Obesity has negative effects not only on physical condition but also on psychological health and social inclusion. Regular physical activity ensures proper energy balance, reduction in body fat percentage and decreases risks of metabolic

disorders (WHO, 2020). At the same time, regular exercise promotes proper immune function, improves the quality of sleep, and benefits general health.

3.2 Effects on Motor Development

Increasingly, motor development has become an important area of investigation in autism research. While autism research used to focus almost exclusively on social communication and behavioral aspects, motor development problems have emerged as one of the defining features of the disorder (Fournier *et al.*, 2010). Individuals with autism can be characterized by poorer gross motor skills, fine motor skills, motor planning, coordination, balance, agility, and ball skills in comparison with their peers.

A meta-analysis by Fournier *et al.* (2010) revealed significantly worse motor performance among people with autism in comparison with typically developed children. The unique deficits in motor skills are especially pronounced for such basic movements as running, jumping, single-leg stance, catching, and throwing. Physical exercise programs that include training for basic movements have proven to be highly effective in improving these skills. Training programs that include basic motor skills training result in the improvement of running, jumping, change of direction, balance, ball skills, coordination, and reaction time (Bremer & Lloyd, 2016).

Improving motor skills leads to increased athletic skills as well as to more independent execution of ADLs. As competence in fundamental movements grows, such fundamental life tasks as stair climbing, dressing, involvement in school activities, and playing become considerably easier (Çamlıbel, 2025).

3.3 Cardiorespiratory Fitness and Muscular Strength

Many researchers have found low aerobic fitness in people with autism (Healy *et al.*, 2018). Low aerobic fitness is associated with rapid exhaustion when performing daily tasks and a tendency to avoid physical activity. Aerobic training, including walking, running, swimming, cycling, and dancing, improves maximum oxygen uptake, strengthens the heart, maintains circulation, and helps increase energy metabolism. Training that develops muscular strength helps maintain correct posture and perform movements correctly.

3.4 Cognitive Development and Executive Functions

It has been demonstrated that not only the musculoskeletal system but also the functioning of the brain is influenced by exercising in recent years. It was stated that regular physical exercises increase attention span, improves memory, and develops problem-solving abilities and cognitive flexibility (Hillman *et al.*, 2008). Deficits in executive functions in people with autism may affect the learning process.

Higher concentrations of the Brain-Derived Neurotrophic Factor (BDNF), dopamine, serotonin, and endorphins in the brain during physical exercises were believed to contribute to synaptic plasticity and learning processes (Ratey & Hagerman,

2008). Specifically, coordination-based movements activate the cerebellum and frontal cortex, contributing to improved attention and planning abilities.

3.5 Effects on Psychological Well-being

There are high incidences of anxiety disorders, stress, behavior problems, and issues with emotional control amongst persons with autism. Studies have shown that consistent physical activity is an effective remedy for dealing with these challenges (Bremer *et al.*, 2016). Physical activities help reduce anxiety, reduce stress levels, reduce aggression, increase self-confidence, and boost happiness levels (Uzun *et al.*, 2025).

According to a systematic review conducted by Lang *et al.* (2010), aerobic activities significantly decrease stereotypic behaviors. Similarly, there is a moderate positive effect of physical activity on behavior regulation as noted in a meta-analysis carried out by Sowa & Meulenbroek (2012).

3.6 Impacts on Social Development

Participation in sports activities is one of the most efficient forms of natural learning, which provides individuals with an opportunity to practice their social skills. More specifically, while participating in team sports and exercising together, individuals get practice in taking turns, sharing, cooperating, following the rules, maintaining eye contact and interacting with other individuals.

Children involved in the swimming program by Pan (2010) have shown great improvement not only in their aquatic motor skills but also in their social behaviors. Moreover, social acceptance is claimed to be increased due to participation in sports activities (Shields *et al.*, 2012).

3.7 Contributions to Quality of Life

The concept of quality of life is quite complex and includes such aspects as physical health, psychological well-being, independence, relationships and environment. For those with autism, active physical exercises will help improve every aspect of quality of life. Physical activity is thus viewed not just as part of rehabilitation but as one of the foundations of health.

4. Recommended Sports Discipline for Individuals with Autism

It is very important to develop physical activity programs for persons with Autism Spectrum Disorder by taking an individual approach. Individuals with ASD have unique features in terms of cognitive development, motor development, sensory processing, communication abilities, behavior, state of health, and interests (American Psychiatric Association [APA], 2022). Thus, there is no sport discipline suitable for everyone with ASD. Sport choice should take into account the chronological age, physical condition, sensory sensitivities, social communication skills, motivation, and family support (Bremer *et al.*, 2016; Dilek & İmamoğlu, 2025).

New evidence shows that a correctly designed sports program not only promotes the improvement of the physical condition of individuals with autism, but also their social communication skills, reduces stereotypic behaviors and increases self-esteem and overall quality of life (Healy *et al.*, 2018). It is especially important to make the chosen activity interesting to the person to keep the program long-term. Besides, starting with individual sports activities before group activities is beneficial for many persons with autism. The sports disciplines recommended in the scientific literature are described below.

4.1 Swimming

Swimming is among the most prescribed and thoroughly researched sports disciplines for people with autism. There are multiple benefits in terms of motor skill development due to reduced gravitational influence and full-body activity. Moreover, hydrostatic pressure and proprioceptive cues from water may help calm children with sensory integration problems. Especially, rich input in terms of touch and proprioception is crucial for the development of sensory regulation skills (Pan, 2010).

Moreover, swimming teaches basic safety and survival skills. Given that autistic children usually show a strong affinity for water, swimming lessons provide essential competences which reduce the risk of accidental drowning. In a controlled experiment conducted by Pan (2010), children with autism who attended 10 weeks of swimming lessons showed not only improved aquatic motor skills, but also an increased level of social communication, eye contact, compliance, and group activity. Further systematic reviews proved the positive influence of swimming on motor skills and social behavior of children with autism (Bremer *et al.*, 2016). The most important aspect of teaching swimming is adaptation of the pool environment to individual sensory sensitivities, especially low noise, working in small groups, and use of visual cues.

4.2 Equestrianism (Hippotherapy)

A relatively novel approach in the sphere of autism that has attracted considerable attention over the last several years is therapeutic horseback riding or hippotherapy. This term stands for special rehabilitation treatments involving the use of the three-dimensional movement pattern of a horse (Bass *et al.*, 2009).

Apart from motor skills, psychological and social changes are especially remarkable. Interaction with the horse helps the child develop a sense of responsibility, trust, and emotional connection. Animal-assisted therapy is found to reduce the level of anxiety, increase the duration of attention spans, and improve social interactions (Bass *et al.*, 2009). Experimental research by Bass *et al.* (2009) shows that during a 12-week hippotherapy treatment, children diagnosed with autism show significant improvement in their social engagement, sensory processing, and attention. The same results were obtained by Gabriels *et al.* (2015) when analyzing the effects of hippotherapy on communication abilities and self-regulatory behavior.

However, all sessions of hippotherapy should be performed by professionals and accompanied by all possible safety measures.

4.3 Athleticism (Running and Walking)

Running and walking are considered two of the easiest ways to introduce physical activity as well as affordable and sustainable throughout one's life. It is well known that aerobic exercises can have numerous advantages for physical health and behavioral regulation in people with autism (Lang *et al.*, 2010).

Also, the psychological impact of such exercises should not be overlooked. The effects of walking and running include the reduction of stress hormones, an increase in endorphins, and the decrease of anxiety (Ratey & Hagerman, 2008). In their systematic review, Lang *et al.* (2010) note that aerobic exercises based on running can lead to the temporary decrease of stereotypical behavior. Programs including outdoor walking are also noted to have a positive impact on attention and behavior regulation.

It is necessary to design a program of running exercises according to the individual physical potential and the principle of gradual loading, as well as motivate participants through gamification.

4.4 Martial Arts

More and more recently, martial arts including judo, karate, taekwondo, and aikido have started appearing among the recommended sports activities for people with autism. The goal of practicing such disciplines is not the formation of aggression but rather the development of self-discipline, self-control, concentration, coordination, and body control. Judo promotes balance, coordination, and falling techniques. Karate and taekwondo are associated with improving reaction time, concentration, flexibility, and movement control.

Bahrami *et al.* (2012) found that stereotypical behavior decreased and social interactions improved in autistic children practicing karate. Also, Movahedi *et al.* (2013) proved that kata training had a positive influence on attention and behavior control. However, all kinds of martial arts should be taught only by coaches with experience in teaching people with special needs. The level of physical interaction, pace of learning, and intensity of exercises should vary depending on individual characteristics.

4.5 Gymnastics

Gymnastics is one of the most necessary sport disciplines recommended to develop fundamental movement skills during childhood. As this discipline requires lots of activities with balance, coordination, agility, and flexibility, it can be considered an important educational tool which contributes to the development of motor skills in autistic children. Fundamental gymnastics skills become the basis for further development of track and field, swimming, basketball, volleyball and other sport disciplines.

According to Bremer and Lloyd (2016), school-based programs focusing on fundamental movement skills increase motor skills in children with autism. Specifically, it was found that balance beam skills, jumping skills, tumbling and somersault maneuvers and coordination obstacle courses help to increase motor skills in children. In gymnastics, task analysis, visual modeling and the use of positive reinforcement can help children learn better.

4.6 Cycling

Cycling can be seen as a lifelong physical activity that can be maintained throughout both childhood and adult years. For people who have autism, cycling training becomes of paramount importance both for their physical development and for acquiring of living independently. Cycling training will assist in the development of independent mobility and transportation skills, enabling the person to participate more actively in the community.

Kelly & Block (2017) found that structured cycling training had a positive effect on balance and coordination of movement of autistic children. Nowadays, special pedagogical techniques aimed at facilitating the transition from bicycles with training wheels to two-wheeled bikes are applied successfully. While in the process of training, it is extremely important to use proper safety gear, to choose safe, traffic-free areas and to use an individual approach in training.

4.7 Other Appropriate Sports Disciplines

Along with those discussed above, the following sports can also be regarded as appropriate for persons with autism:

- **Yoga:** Helps in developing balance, breath control, and relaxation.
- **Dancing:** Increases rhythm perception and coordination abilities.
- **Table Tennis:** Helps in developing coordination between hands and eyes and attention development.
- **Archery:** Helps in improving attention, concentration, and self-control.
- **Rowing and Canoe Ergometer:** May help increase upper extremities' strength and endurance.
- **Bocce and Bowling:** Are recreational disciplines that may develop coordination and participation in social activities, especially for those with mild motor dysfunctions.

Choosing these sports must be made according to one's own interest, physical capabilities, and health condition.

5. Planning Exercise Programs

In order to plan exercise programs for people diagnosed with Autism Spectrum Disorder (ASD), more caution should be taken as compared to the typically developing population. It is important to keep in mind that people with autism possess a high degree

of heterogeneity regarding their intellectual functioning, motor skills, communication abilities, sensory sensitivities, behavior, and learning pathways (APA, 2022). It is thus important to consider the level of performance of the individual, set goals accordingly, and create a program tailored specifically to his or her needs.

Research indicates that individualized physical activity programs can help to improve the motor skills, increase physical fitness, reduce problem behaviors, and encourage social engagement in people with autism (Bremer *et al.*, 2016; Healy *et al.*, 2018). It is therefore important for exercise intervention to focus not only on developing the movement skills of the individual, but also on increasing his or her independence and quality of life.

5.1 Individualization

Individualization is the primary criterion that must be considered when organizing exercises for persons with autism. During program creation, the individual's:

- age,
- cognitive maturity,
- motor ability,
- communicative ability,
- sensory profile,
- fitness condition, and
- personal preferences must be considered.

Some people easily adjust to group activities, but for others, more successful results can be gained through one-on-one training. Furthermore, while some children like dynamic and energetic activities, others would prefer to take part in calmer exercises because of their sensory issues. Thus, instead of applying one type of exercise for everyone, flexible programs according to the characteristics of the individual need to be organized (Lang *et al.*, 2010). Determining the individual's strengths from the very beginning and starting the training with easy activities will encourage intrinsic motivation in the individual.

5.2 Application of Visual Supports

An ample number of people with autism understand visual information better than verbal information. This means that using visual supports when teaching exercise makes learning much easier (Mesibov & Shea, 2010).

The following tools may be used in the exercise classes: illustrated movement cards, visual cue cards, activity schedule cards, visual timetable cards, and video modeling (Kaya & Alp, 2022). For instance, illustrating visually the stages of a PE lesson, including introduction, warming up, exercise routines, games, and winding down, enables an individual to be ready for the lesson. Moreover, visual supports decrease anxiety and increase adaptability to new things.

5.3 Routine and Structured Learning Environment

For autistic people, routine and a structured environment help build their security and confidence. Since unexpected situations may cause anxiety and behavior problems, exercise sessions should be organized in an environment that is consistent and structured (Mesibov & Shea, 2010).

When the sessions are organized in a routine manner, scheduled at specific times, follow definite rules, and inform participants about changes in activities, this helps the person adapt to the environment (Dönmez, 2019). For example, organizing a consistent lesson schedule consisting of greeting, warm-up, basic movement practice, and games gives them a chance to know what to expect from the session.

5.4 Progressive Teaching Method

Learning new motor skills may take some time for persons with autism. In such cases, decomposition of a complicated action into smaller understandable actions (task analysis) is advised (Lang *et al.*, 2010).

For example, motor skills like cycling can be learned in stages, i.e., mounting the cycle, balancing on it, cycling, controlling direction, and cycling independently. Likewise, in sports like swimming, gymnastics, or ball playing, actions need to become progressively more difficult. Such an approach enhances the sense of accomplishment in the person, which encourages learning.

5.5 Reinforcement and Motivation

The principles of behavioral learning are critical for the development of new skills for people with autism. Proper reinforcement of effective behavior increases the individual's desire to perform the action (Cooper *et al.*, 2020).

The method of reinforcement can take the following forms: verbal encouragement, social reinforcement, engagement in preferred activities, and small motivational tokens. Nevertheless, it is important that the choice of the methods corresponds to the individual's characteristics. The motivators of different individuals can be quite different – some people are very motivated by social encouragement, while others prefer access to the desired activity (Görgün & Melekoğlu, 2016).

5.6 Intensity of Exercises and Safety Measures

Intensity of exercises is dependent on the level of functional ability of the individual and should be modified according to the capacity of the individual. At the start, exercises with low to moderate intensity can be undertaken and gradually increased with respect to time (WHO, 2020).

Moreover, safety measures must be taken in the exercise environment. It is important to consider equipment, environment stimulation, personal needs, and supervision by instructors or coaches (Kara *et al.*, 2019).

5.7 Exercise Duration and Intensity

Accurate assessment of duration, frequency, and intensity is vital when developing exercise programs for people with Autism Spectrum Disorder (ASD). For exercise to bring benefits, a training load model, which would correspond to the person's level of development, physical fitness, motor skills, and health condition, must be developed. Exercises conducted at an extremely low intensity and with irregular frequency might not have a positive impact on the person's development; moreover, too intense exercises might cause fatigue, demotivation, and behavioral problems (American College of Sports Medicine, 1986).

According to the recommendations of the World Health Organization (WHO, 2020), children and adolescents must do at least 60 minutes of moderate and vigorous exercise per day. At the same time, it is noted that most of these exercises must be aerobic, and three times a week must include exercises with higher intensity aimed at strengthening the muscles and bones. However, due to the low levels of physical activity among people with autism, it is recommended to start exercising with shorter periods and lower intensities (Jones *et al.*, 2017).

At the initial stage of exercise programs for people with autism, the following parameters are considered an adequate starting point:

- **Duration of the session:** 20-30 minutes
- **Frequency:** 2-3 sessions a week.

As the person adapts to the program, its frequency and duration must be increased gradually. During later stages, it is possible to target the following objectives:

- **Frequency:** 4-5 physical activity sessions a week,
- **Duration of the session:** 45-60 minutes (Bremer *et al.*, 2016; Healy *et al.*, 2018).

The exercise intensity should consider both the physical abilities and the behavioral traits of the individual. The moderate intensity exercise is associated with the ability of the individual to talk but without the possibility to make longer phrases (the 'talk test'). High intensity is associated with higher physical demand of the activity and higher breath frequency (WHO, 2020). Low-to-moderate intensity exercises should be chosen for individuals with autism, especially in the beginning period of the exercise. The options for this period include walking, jogging, swimming, cycling, dancing, gymnastics and playful exercises. With the progress of the program, it will be possible to include resistance training, coordination and more intense aerobic exercises in line with the individual's physical growth (Healy *et al.*, 2018). Progressive overload must form the basis for any increase in exercise time and intensity. In this system, it is advisable to start with an increase in the time of the exercise period, and then the frequency and intensity may be increased gradually. For instance, an exercise plan that starts with a 20-minute walk two times a week can be progressed to 30 minutes first, and then four times a week. However, when it comes to exercise programming for people with autism, it is important to monitor behavioral and psychological changes in addition to physiological changes. For some people, engaging in prolonged or vigorous exercise can cause sensory overload, increased anxiety, or withdrawal. Thus, fatigue, motivational levels, attention levels, and

behavior should be constantly checked throughout the session (Lang *et al.*, 2010). It is also necessary to choose exercises that one likes in order to maintain long-term participation in the program. Fun and gamified activities with social interaction contribute to better adherence and lifetime physical activity (Bremer *et al.*, 2016).

6. Challenges Encountered in Sports Applications

Sports and physical activity participation by people suffering from ASD is associated with a combination of various physical, psychological, environmental, and social elements. While there is no doubt about the positive impact of physical activity on motor skills, physical fitness, social communication, and overall quality of life, the physical activity participation rates in autistic individuals significantly lag behind their typical peers' rates (Jones *et al.*, 2017). The problem does not result from individual traits alone; rather, it appears to be based on a combination of barriers that occur due to a variety of reasons linked to the family, educational, sporting, and social environment.

Scientific studies show that barriers affecting the physical activity participation of autistic individuals appear on different levels, including motor and behavioral problems on the individual level, lack of peer support and inclusion on the social level, and a lack of adapted settings and specialists on the environmental level (Bandini *et al.*, 2015; Salar *et al.*, 2024). Hence, overcoming these barriers within the context of sports applications requires multi-faceted efforts on different levels.

6.1 Lack of Trained Coaches and Specialists

The major problem that can discourage individuals with autism from participating in sports activities is the lack of well-trained coaches who have all the necessary knowledge and experience required to work with people with special needs. As conventional sports training programs mainly focus on typical audiences, coaches lacking necessary skills in communication, sensory perception, and behavior of people with autism face numerous difficulties during training (Obrusnikova & Miccinello, 2012).

To work successfully with people with autism, coaches should have basic information about autism features, apply personalized educational approaches, use visual aids, have basic behavior management skills, and take into account personal sensory peculiarities.

According to recent studies, the key factors that contribute to sports involvement of people with autism are coach training and adapted physical education specialists (Salar *et al.*, 2024). Thus, the development of an inclusive curriculum for coaches regarding working with people with special needs becomes crucial in sports education programs.

6.2 Lack of Suitable Sports Facilities and Physical Environment

The lack of an appropriate physical environment in the case of sports is yet another important issue that has an impact on participation in sports among people who have

autism. Noise, lighting, crowds, complexity of the design of facilities and lack of safety can induce sensory overload in some people who have autism (Schaaf & Lane, 2015).

Although many sports facilities may be physically accessible, they may not be organized in ways that take into account the sensory and behavioral requirements of people with autism. For example, loud music, whistles blowing, or crowded changing rooms could cause some people to feel anxious. Consequently, sports settings need to include quieter zones, visual structuring, safe movement opportunities, and time to adapt (Salar *et al.*, 2024).

6.3 Problems with Insufficient Families' Awareness and Assistance

The participation of families in the physical activity of people with autism plays an important role. The majority of kids rely on family assistance in order to obtain access to sporting facilities, participate in the programs and remain engaged for a long period of time (Bandini *et al.*, 2015).

While focusing on educational and therapeutic approaches, some families may perceive physical activities as something that is less important than their developmental significance. In spite of this, physical activities become an important instrument which strengthens the special education processes as far as it concerns the issues of motor development, socialization and independent living (Healy *et al.*, 2018).

6.4 Economic Barriers

Cost is yet another important element that affects the participation of people with autism in sports programs. Personalized sports programs provided by coaches, costs of transport, and special equipment can become quite expensive for some families (Salar *et al.*, 2024).

Especially in poor families, less costly options, such as physical activity at home or unstructured sports programs, may be preferred over organized sports programs. In this way, chances for participation of individuals with autism in high-quality sports programs decrease. Hence, development of inexpensive sports programs by public organizations, cities, and sports clubs is crucial.

6.5 Sensory Sensitivities

The sensory processing issues seen in people with autism can be barriers when it comes to their ability to adapt to sports environments. People can either be oversensitive to certain stimuli such as noise, bright lights, touch, and crowded areas, or look for sensory stimulation (Schaaf & Lane, 2015). In order to minimize the effects of sensory sensitivities, exposure to the sports environment in advance, using visual schedules, small group work, and sufficient time to allow for the person's adaptation can be considered helpful.

6.6 Behavioral Problems and Social Prejudices

The problems of attention, resistance to changes in the environment, anxiety and behavioral reactions seen in people diagnosed with autism may cause problems for such

people in sports arenas. These behavioral problems must be frequently considered in terms of functional responses to environmental factors (APA, 2022).

In addition, misconceptions and social prejudices in society also affect the practice of sports. The social belief that autistic people are not good enough to participate in sports creates barriers for such individuals in sports activities (Shields *et al.*, 2012). Creating an inclusive approach to sports will not only support the right to sports for these people, but also increase societal awareness about diversity.

6.7 Solutions and Multidisciplinary Approach

A multidisciplinary approach is crucial for overcoming the obstacles faced by individuals with autism concerning their sports participation. It should be mentioned here that the cooperation of sports scientists, special education experts, physiotherapists, psychologists, families, and coaches is required. Effective sports programs are characterized by the assessment of personal traits, establishment of adequate goals, environmental adaptation, and involving the family (Healy *et al.*, 2018).

To sum up, the problems preventing the participation of individuals with autism in the practice of sports are caused by more than just their personal traits. Such factors as the lack of skilled professionals, the absence of proper infrastructure, economic barriers, lack of family involvement, sensory sensitivity, and social stigma are among the most significant barriers. Therefore, it is necessary to create inclusive sports policies and foster interdisciplinary cooperation (Elaltunkara, 2017).

7. Conclusion

In people with autism, sports should not only be viewed as an exercise modality that increases physical fitness but as a vital life skill that contributes to mental, psychological, and social development. Not only do well-organized and structured exercise programs help develop motor coordination, but they also facilitate communication skills, decrease behavioral problems, and increase the general quality of life. Consequently, interdisciplinary collaboration that would involve experts from the fields of sports science, special education, physiotherapy, psychology, and families is vital in order to reach the desired outcomes. Further research in terms of large-scale randomized controlled trials in the future would help identify what type of exercise would be more effective for different age groups.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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References

- Aksoy, Y. (2020). Rekreatif faaliyet olarak fiziksel aktivitelerin otizmli çocuklarda sosyal iletişime yönelik etkileri. *Gaziantep Üniversitesi Spor Bilimleri Dergisi*, 5(1), 1-9. Retrieved from <https://dergipark.org.tr/tr/pub/gaunjss/article/689747>
- American College of Sports Medicine. (1986). *Guidelines for exercise testing and prescription*. Lea & Febiger. Retrieved from <https://acsm.org/education-resources/books/guidelines-exercise-testing-prescription/>
- American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.; DSM-5-TR). American Psychiatric Publishing. Retrieved from <https://www.psychiatry.org/psychiatrists/practice/dsm>
- American Psychiatric Association. (2022). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed., text rev.). <https://doi.org/10.1176/appi.books.9780890425787>
- Arslan, E. (2019). Otizm ve spor. *Spor bilimler alanında araştırma makaleleri*, 105-127.
- Aydın, İ., & Sarol, H. (2016). Otizmli bireylerin Fiziksel Aktivite Programlarına Katılımını Engelleyen Faktörlerin İncelenmesi. *International Journal of Sport Culture and Science*, 2(Special Issue 1), 870-880. Retrieved from <https://dergipark.org.tr/en/pub/intjsscs/article/108137>
- Bahrami, F., Movahedi, A., Marandi, S. M., & Abedi, A. (2012). Kata techniques training consistently decreases stereotypy in children with autism spectrum disorder. *Research in developmental disabilities*, 33(4), 1183-1193. <https://doi.org/10.1016/j.ridd.2012.01.018>
- Balci, M., Şimşek, N. M., & Işık, Ö. (2024). Otizm Spektrum Bozukluğu Olan Çocuklarda Spor Okullarının Fiziksel Aktivite Düzeyine, Uyku ve Yaşam Kalitesine Etkisi. *Fikriyat*, 4(1), 12-26. <https://doi.org/10.61960/fikriyat.1449734>
- Bandini, L. G., Curtin, C., Phillips, S., Anderson, S. E., Maslin, M., & Must, A. (2017). Changes in food selectivity in children with autism spectrum disorder. *Journal of*

- autism and developmental disorders*, 47(2), 439-446. <https://doi.org/10.1007/s10803-016-2963-6>
- Bass, M. M., Duchowny, C. A., & Llabre, M. M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of autism and developmental disorders*, 39(9), 1261-1267. <https://doi.org/10.1007/s10803-009-0734-3>
- Bremer, E., & Lloyd, M. (2016). School-based fundamental-motor-skill intervention for children with autism-like characteristics: An exploratory study. *Adapted Physical Activity Quarterly*, 33(1), 66-88. <https://doi.org/10.1123/apaq.2015-0009>
- Bremer, E., Crozier, M., & Lloyd, M. (2016). A systematic review of the behavioural outcomes following exercise interventions for children and youth with autism spectrum disorder. *Autism*, 20(8), 899-915. <https://doi.org/10.1177/1362361315616002>
- Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis* (Vol. 2, pp. 37-46). Upper Saddle River, NJ: Pearson/Merrill-Prentice Hall. <https://doi.org/10.1901/jaba.2010.43-161>
- Çamlıbel, B. B. (2025). Fiziksel aktivite ve sporun otizm spektrum bozukluğu olan bireylerin iletişim, sosyal ve motor becerileri üzerindeki etkileri: Sistematik bir derleme. Retrieved from <https://acikerisim.uludag.edu.tr/bitstreams/af64038c-c410-4c23-98bc-2d1e78023089/download>
- Dilek, A. N., & İmamoğlu, O. (2025). The effect of motivation and amotivation on optimal performance emotion state in sports sciences faculty students. *International Journal of Health, Exercise and Sport Sciences*, 2, 283-292. <https://doi.org/10.5281/zenodo.17429962>
- Doğan, E., Sekban, G., Çoruh, Y., İmamoğlu, O., & Ermiş, A. (2025). Examination of the relationship between motivation and dispositional flow in team and combat sports athletes. *International Journal of Sport Exercise and Training Sciences (IJSETS)*, 12, 131-140. <https://doi.org/10.18826/useeabd.1610210>
- Dönmez, M. U. (2019). Otizmlı bireylerde fiziksel aktivite uygulamalarının bazı fizyolojik ve psikolojik parametreleri üzerine etkisi: alanyazın derlemesi. *Academic Studies on Natural and Health Sciences*, 607. Retrieved from <https://dergipark.org.tr/tr/pub/atdd/article/1371678>
- Elaltunkara, C. (2017). 16 haftalık spor eğitiminin otizmlı çocuklarda temel motor becerileri üzerine etkisi (Master's thesis, Bartın University (Turkey)). Retrieved from <https://acikerisim.bartın.edu.tr/entities/publication/fb52792d-5d6b-45ea-abf1-6efc45f367ff>
- 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. <https://doi.org/10.1007/s10803-010-0981-3>
- Gabriels, R. L., Pan, Z., Dechant, B., Agnew, J. A., Brim, N., & Mesibov, G. (2015). Randomized controlled trial of therapeutic horseback riding in children and adolescents with autism spectrum disorder. *Journal of the American Academy of*

- Child & Adolescent Psychiatry*, 54(7), 541-549.
<https://doi.org/10.1016/j.jaac.2015.04.007>
- Görgün, B., & Melekoğlu, M. A. (2016). Otizm spektrum bozukluğu (OSB) olan bireylerin fiziksel aktivitelerine ilişkin yapılan çalışmaların gözden geçirilmesi. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi*, 17(03), 347-376. Retrieved from <https://dergipark.org.tr/tr/pub/ozelegitimdergisi/article/268559>
- Healy, S., Nacario, A., Braithwaite, R. E., & Hopper, C. (2018). The effect of physical activity interventions on youth with autism spectrum disorder: A meta-analysis. *Autism Research*, 11(6), 818-833. <https://doi.org/10.1002/aur.1955>
- Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart. *Nature Reviews Neuroscience*, 9(1), 58-65. <https://doi.org/10.1038/nrn2298>
- İnce, G. (2017). Otizm spektrum bozukluğu olan çocuğa sahip ebeveynlerin spor ile ilgili görüşleri. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi*, 18(01), 109-124. Retrieved from <https://dergipark.org.tr/en/pub/ozelegitimdergisi/article/302891>
- Jones, R. A., Downing, K., Rinehart, N. J., Barnett, L. M., May, T., McGillivray, J. A., ... & Hinkley, T. (2017). Physical activity, sedentary behavior and their correlates in children with autism spectrum disorder: A systematic review. *PloS one*, 12(2). <https://doi.org/10.1371/journal.pone.0172482>
- Kara, E., Beyazoglu, G., & Uysal, E. (2019). Otizmlı çocuklarda temel hareket eğitiminin fiziksel uygunluk parametreleri üzerine etkisi. *SPORMETRE Beden Eğitimi ve Spor Bilimleri Dergisi*, 17(1), 88-102. Retrieved from <https://dergipark.org.tr/tr/pub/spormetre/article/503317>
- Kaya, K., & Alp, H. (2022). Otizmlı çocuklarda beden eğitimi ve sporun önemi üzerine yapılmış araştırmaların incelenmesi: Meta analiz. *Uluslararası Spor Bilimleri Öğrenci Çalışmaları*, 4(1), 1-7. Retrieved from <https://dergipark.org.tr/tr/pub/i4s/article/1081463>
- Kaya, L., Gültekin, G. I., Şahin, M., & Kırandı, Ö. (2020). Spor dersi alan otizm spektrum bozukluğu olan çocukların ebeveynlerinin yaşam kalitesi düzeyi. *Spor Eğitim Dergisi*, 4(2), 190-202. Retrieved from <https://dergipark.org.tr/tr/pub/seder/article/702842>
- Kelly, L. E., Block, M. E., & Colombo-Dougovito, A. M. (2017). Physical education. *Handbook of special education*, 586-605.
- 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. <https://doi.org/10.1016/j.rasd.2010.01.006>
- Lloyd, M., MacDonald, M., & Lord, C. (2013). Motor skills of toddlers with autism spectrum disorders. *Autism*, 17(2), 133-146. <https://doi.org/10.1177/1362361311402230>

- Lord, C., Brugha, T. S., Charman, T., Cusack, J., Dumas, G., Frazier, T., ... & Veenstra-VanderWeele, J. (2020). Autism spectrum disorder. *Nature reviews Disease primers*, 6(1), 5. <https://doi.org/10.1038/s41572-019-0138-4>
- Maenner, M. J. *et al.* (2023). Prevalence and characteristics of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2020. *MMWR. Surveillance summaries*, 72. <https://doi.org/10.15585/mmwr.ss7202a1>
- Mesibov, G. B., & Shea, V. (2010). The TEACCH program in the era of evidence-based practice. *Journal of Autism and Developmental Disorders*, 40, 570–579. <https://doi.org/10.1007/s10803-009-0901-6>
- Obrusnikova, I., & Miccinello, D. L. (2012). Parent perceptions of factors influencing after-school physical activity of children with autism spectrum disorders. *Adapted Physical Activity Quarterly*, 29(1), 63–80. <https://doi.org/10.1123/apaq.29.1.63>
- Pan, C. Y. (2010). Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. *Autism*, 14(1), 9–28. Retrieved from <https://doi.org/10.1177/1362361309339496>
- Ratey, J. J., & Hagerman, E. (2008). *Spark: The revolutionary new science of exercise and the brain*. Little, Brown and Company. Retrieved from <https://psycnet.apa.org/record/2008-02933-000>
- Schaaf, R. C., & Lane, A. E. (2015). Toward a best-practice protocol for assessment of sensory features in ASD. *Journal of Autism and Developmental Disorders*, 45(5), 1380–1395. <https://doi.org/10.1007/s10803-014-2299-z>
- Shields, N., Synnot, A. J., & Barr, M. (2012). Perceived barriers and facilitators to physical activity for children with disability: a systematic review. *British journal of sports medicine*, 46(14), 989–997. <https://doi.org/10.1136/bjsports-2011-090236>
- Sowa, M., & Meulenbroek, R. (2012). Effects of physical exercise on autism spectrum disorders: A meta-analysis. *Research in Autism Spectrum Disorders*, 6(1), 46–57. <https://doi.org/10.1016/j.rasd.2011.09.001>
- Taner, İ. (2020). *Otizm spektrum bozukluğu olan bireylerde spor eğitiminin fiziksel uygunluk, öz bakım, sosyal ve akademik becerilere etkisi* (Master's thesis, Sakarya University of Applied Sciences (Turkey)).
- Tyler, K., MacDonald, M., & Menear, K. (2014). Physical activity and physical fitness of school-aged children and youth with autism spectrum disorders. *Autism research and treatment*, 2014(1). <https://doi.org/10.1155/2014/312163>
- Uzun, R. N., Özkan, R., & İmamoğlu, O. (2025). An investigation into athletes' perceived mental fatigue awareness. *International Journal of Sport Exercise and Training Sciences (IJSETS)*, 11, 402–407. Retrieved from <https://dergipark.org.tr/en/pub/useeabd/article/1819487>
- World Health Organization. (2020). *WHO Guidelines on Physical Activity and Sedentary Behaviour*. Geneva: World Health Organization. Retrieved from <https://doi.org/10.1136/bjsports-2020-102955>