applied sciences

MDPI

Article

Motor Competence and Sports Practice in Children with Autism Spectrum Disorder: Pilot Study in Gymnastics

Geraldine Quito [1], Miguel Jacinto [1,2,*], Nuno Amaro [1,2], Diogo Monteiro [1,2], Rui Matos [1,2], Susana Diz [1,2], Tânia Mira [2,3] and Raúl Antunes [1,2]

[1] ESECS—Polytechnic University of Leiria, 2411-901 Leiria, Portugal; 1221185@my.ipleiria.pt (G.Q.); nuno.amaro@ipleiria.pt (N.A.); diogo.monteiro@ipleiria.pt (D.M.); rui.matos@ipleiria.pt (R.M.); susana.diz@ipleiria.pt (S.D.); raul.antunes@ipleiria.pt (R.A.)
[2] Research Center in Sport Sciences, Health Sciences and Human Development (CIDESD), 5000-558 Vila Real, Portugal; taniaslmira@gmail.com
[3] ISCE—Polytechnic University of Lisboa and Tagus Valley, 2620-379 Lisboa, Portugal
* Correspondence: miguel.s.jacinto@ipleiria.pt

Abstract: The practice of physical activity, exercise, and sports brings various benefits to the general population. However, a few intervention programs involving physical activity and sports have been specifically designed for children with Autism Spectrum Disorder (ASD). The present study aimed to evaluate the effects of implementing a sports program based on gymnastics (specifically trampolines) on the motor skills of children with ASD. The program ran from September to May 2024 (8 months duration) using the Motor Competence Assessment Battery (MCA) as an evaluation tool. It included three typically developing children and three children with ASD, all aged between 4 and 5 years. The program sessions lasted 45 min and took place twice a week. The MCA Battery was administered to assess motor skills before and after the intervention. After the intervention program, significant differences were found only between moments in the Shuttle Run test (pre-intervention ≠ and post-intervention; Bonferroni correction: $t = -2.00$; $p = 0.043$; $w = 0.33$). Based on these results, we can conclude that practicing a sports program based on gymnastics (namely trampolines) can contribute to improving the motor skills of children with ASD.

Keywords: motor competence; sports; trampoline gymnastics; autism spectrum disorder

Academic Editor: Nicola Magnavita

Received: 3 December 2024
Revised: 27 December 2024
Accepted: 29 December 2024
Published: 2 January 2025

Citation: Quito, G.; Jacinto, M.; Amaro, N.; Monteiro, D.; Matos, R.; Diz, S.; Mira, T.; Antunes, R. Motor Competence and Sports Practice in Children with Autism Spectrum Disorder: Pilot Study in Gymnastics. *Appl. Sci.* **2025**, *15*, 373. https://doi.org/10.3390/app15010373

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that leads to deficits in communication and social interaction [1]. In children with ASD, motor and sensory difficulties are commonly observed [2]. Regarding the gross motor skills of these individuals, they report that movements may be poor, slow, or delayed in execution, with difficulties in motor initiation, gesture initiation, and balance control [3].

Physical activity plays an important role in the quality of life of these individuals and has been widely considered as an essential strategy for promoting physical fitness [4,5]. Studies such as those by Healy et al. [6] demonstrate that regular and structured physical exercise can improve motor skills, contributing to a better quality of life for children with ASD. Additionally, physical exercise is widely recognized as an effective means of preventing motor problems in the general population, and it is likely to have positive effects on the ASD population as well [7].

In this context, using the Motor Competence Assessment (MCA) as an evaluation tool, a motor intervention program was specifically designed to assess the effect of the program on the sports practice of trampoline gymnastics in children with ASD. Physical activity programs that use trampolines have been employed in various fields as they seem to promote motor development in children [8,9].

Thus, this project aims to explore the benefits of a gymnastics (trampoline) program for children with ASD, particularly regarding their quality of life and motor development. We believe that this work can contribute to a better understanding of the role of such programs for children with ASD and, consequently, to the definition of better intervention strategies for these children.

1.1. Autism Spectrum Disorder

ASD is a common developmental disorder characterized by difficulties in speech and behaviors, such as lack of social skills, repetitive behaviors, communication disorders, and limited activities and interests [10,11]. Many children with ASD experience motor and sensory difficulties [2]. Several studies have also reported changes in the motor development profiles of these children that contribute to lower physical fitness [12–14].

ASD has historically been considered a pathological condition, based on the current Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria [1]: "Autism includes three severity levels ranging from "requiring support" to "requiring very substantial support." Severity judgments are based solely on the characteristics of the two main domains that constitute the diagnostic criteria. The first domain involves deficits in social communication skills (i.e., social affect). These may manifest, for example, in the inability to use eye contact to initiate communication with others as well as in social interactions that lack naturalness. The second central domain is the presence of restricted or repetitive patterns of behavior and interest. This can range from engaging in repetitive movements, such as hand-flapping, to an intense focus on specific objects or topics." Each degree of severity corresponds to the support of the individual needs: (i) level 1—does not need support, has moderate difficulties in social interactions and adapting to changes; (ii) level 2—needs significant support, has significant limitations in communication and repetitive behaviors; (iii) level 3—needs very significant and constant support, has severe deficits in communication and intense repetitive and restrictive behaviors.

ASD results from neurological dysfunction with prenatal onset, as demonstrated by neuropathological studies that showed early brain development anomalies, which persist throughout life and result in atypical neurodevelopment [15,16].

1.2. Motor Competence

According to D'Hondt et al. [17], motor competence can be defined as the quality of a person's movement coordination when performing different motor skills, continuously varying between gross motor skills (e.g., running) and fine motor skills (e.g., manual dexterity). Furthermore, motor competence (MC) also plays a significant role in adherence to physical activity, creating a bidirectional relationship. The development of MC in children with ASD has been recognized as a crucial factor for regular involvement in physical activity throughout life [18,19].

Motor competence is a term that describes goal-directed human movement [20]. Generally, it can also be described as the ability of a person to be "proficient" in a wide range of both fine and gross motor skills [21]. Motor competence is the ability to control degrees of movement and the functional maintenance of time and space relationships between body segments [22,23]. This should be considered an essential aspect of a child's motor development. Fundamental motor skills emerge even before birth, and during the first years of life, they are acquired, developed, and refined [24]. Motor competence has

become a relevant topic in the educational field, not only linked to physical development but also to cognitive, psychological, and social aspects [25].

1.3. Development and Characterization of Motor Competence in Autism Spectrum Disorder

In children with ASD, development follows a sequential nature, where one acquisition leads to another in an orderly and irreversible pattern [26,27]. Changes throughout the life cycle are facilitated by the interaction between task demands, the individual's biology, and environmental conditions [28,29]. Stodden et al. [18] suggested that participation in physical activity stimulates motor competence in young children and that higher levels of physical activity provide more opportunities to develop motor skills.

Bardid et al. [30] emphasized that the complexity of motor competence means that it cannot be captured by simply measuring a specific skill or even a set of skills (i.e., fine or gross motor). Measuring motor competence can be objective, subjective, or a hybrid of both types of measurement, with each form having its own unique set of strengths and limitations [28].

In addition to the core symptoms of social interaction, communication, and stereotyped behavior, the motor skills of individuals with ASD typically exhibit delays [14]. The acquisition and execution of motor skills depend on coordinated activity within a network of cortical and subcortical regions [31]. Deficits in motor skill development may be present before deficits in social interaction and communication, and motor skill deficits can exacerbate deficits in social and communication skills such as social interaction [32].

It is important for children with ASD to have the opportunity to develop their motor skills. Development is a continuous process of change that an individual undergoes during growth and maturation [33]. It is related to age but does not depend solely on it.

According to Venetsanou and Kambas [34], the development of motor skills during childhood depends on, and is influenced by, morphological, physiological, and neuromuscular factors. A structured motor skill training program for children aged 3 to 6 years can improve their motor skills, health, cognition, and well-being, potentially benefiting their overall development [35].

Children with ASD show impairments in postural control, motor planning, and motor imitation, which can directly affect their ability to perform age-appropriate motor skills [36]. Children with ASD may have difficulty performing age-appropriate motor skills due to specific motor deficits or differences in other domains that affect the way they learn motor skills [37]. Most of the evidence suggesting that individuals with ASD demonstrate motor delays has focused on comparisons with normative samples. Early research found differences in gait between children with ASD and children without ASD, including reduced stride lengths and increased stance times [38].

1.4. Sports Practice in Children with Autism

Physical activity refers to all types of physical actions that consume energy due to skeletal muscle contraction, including physical exercise, work, household tasks, entertainment, and other activities [39]. Research has highlighted the positive impact of physical activity and physical exercise in preventing diseases such as type II diabetes, hypertension, and obesity [40,41], as well as its contribution to improving physical fitness, with benefits for overall health, quality of life, and average life expectancy [42,43]. In this regard, different studies have shown that engaging in physical activity, physical exercise, and sports is associated with improved well-being and quality of life in children [41]. A physical activity intervention program significantly improves perceptions of physical fitness and body appearance.

Individuals with ASD constitute a special risk group due to their sedentary lifestyle, which increases the risk of heart disease, diabetes, and obesity [44]. Physical activity

intervention significantly improves social interaction, communication, motor skills, and the degree of ASD in children and adolescents with ASD but does not significantly affect stereotypical behavior [45]. The social and communication deficits in individuals with ASD make them less likely to engage in sports activities and interact with others, which can lead to a sedentary lifestyle [13].

Studies have shown that sports practice improves deficits in social interaction, reduces aggressive behaviors [46], and decreases stereotypical behaviors in children, adolescents, and adults with ASD [47]. Recently, it has been shown that combined physical training improves restricted and repetitive behavior patterns, as well as social skills in children with ASD [48]. Moreover, physical exercise has a positive influence on various symptoms and comorbidities such as reduced physical motor deficits [49].

1.5. Benefits of Sports Practice in Children with Autism Spectrum Disorder

Sports practice has been associated with improvements in social and communication skills [50], along with facilitating community inclusion [51]. Children with ASD may be at risk of inactivity due to social and behavioral deficits commonly associated with the condition, such as difficulties in understanding social cues, making eye contact, engaging in imaginative and social play, participating in sharing/taking turns, reciprocal conversations, and making friends [52,53].

Regular physical activity is determined by three interacting factors: environmental, personal, and behavioral factors [54]. Therefore, participation in physical activity for children and adolescents with ASD can offer a range of physical, psychological, and social benefits in addition to improving motor skills and motor control [55] and enhancing overall physical condition and health [56]. Recent studies suggest that physical activity practices in young children with developmental delays can lead to significant gains in motor skills in a short period [57,58].

A recent meta-analysis found that the positive effects of physical activity in youth with ASD were most pronounced for fine motor coordination, locomotor skills, muscular strength/endurance, and social functioning [6]. Therefore, it is essential to encourage and support the participation of children with ASD in sports activities in order to improve their quality of life and social inclusion.

A study by Connor-Kuntz and Dummer [59] found significant gains in fundamental motor skills from pre-test to post-test in typical preschool children, Head Start children (disadvantaged), and preschool children with disabilities because of an 8-week physical activity intervention program. According to Hamilton et al. [60], they discovered that, before a motor intervention program, disadvantaged preschool children showed delays in the development of object control skills. After an 8-week assisted intervention, they found significant gains in object control skills from the pre-test to the post-test in the experimental group.

1.6. Current Study

Given the importance of appropriate motor development for the quality of life of children, especially those with ASD, it is essential to investigate interventions that can promote improvements in their motor skills. Furthermore, the development of tailored and structured programs that address their specific needs can be a useful tool for consultations by professionals, institutions, and/or organizations working with this population. Therefore, the present study prescribes, implements, and analyzes, in more depth, the impact of a structured sports program in the modality of gymnastics, focusing on trampolines, on the motor development of children with ASD.

The general objective of this study is to investigate the effects of implementing a sports program based on gymnastics (specifically trampolines) on the motor competence

of children diagnosed with ASD. As a specific objective, the present study aims to develop an adapted trampoline gymnastics intervention program tailored to the specific needs of children with ASD, developmental delays, and developmental concerns, and to evaluate the effect of the intervention program on motor competence (both gross and fine motor skills) in children with ASD, using the MCA Battery as the evaluation tool.

2. Materials and Methods

2.1. Participants

Three children aged 4 to 5 years without ASD and three children aged 4 to 5 years with ASD were included in this project. Two of the participants had grade 1 autism and one had grade 2 autism. The children with ASD included in this project were selected based on the recommendations of the schools they attended. The early intervention teams from these schools suggested the inclusion of additional motor activities to the families, as the children were not achieving the expected results in motor skills at the time. Therefore, all of these children were starting sports practice for the first time, with the goal of improving motor development through participation in guided physical activities, specifically in trampoline gymnastics.

Oral consent was obtained from the participants, and written consent was obtained from their parents/legal guardians before the project began.

Figure 1 shows the flowchart of the participants under study.

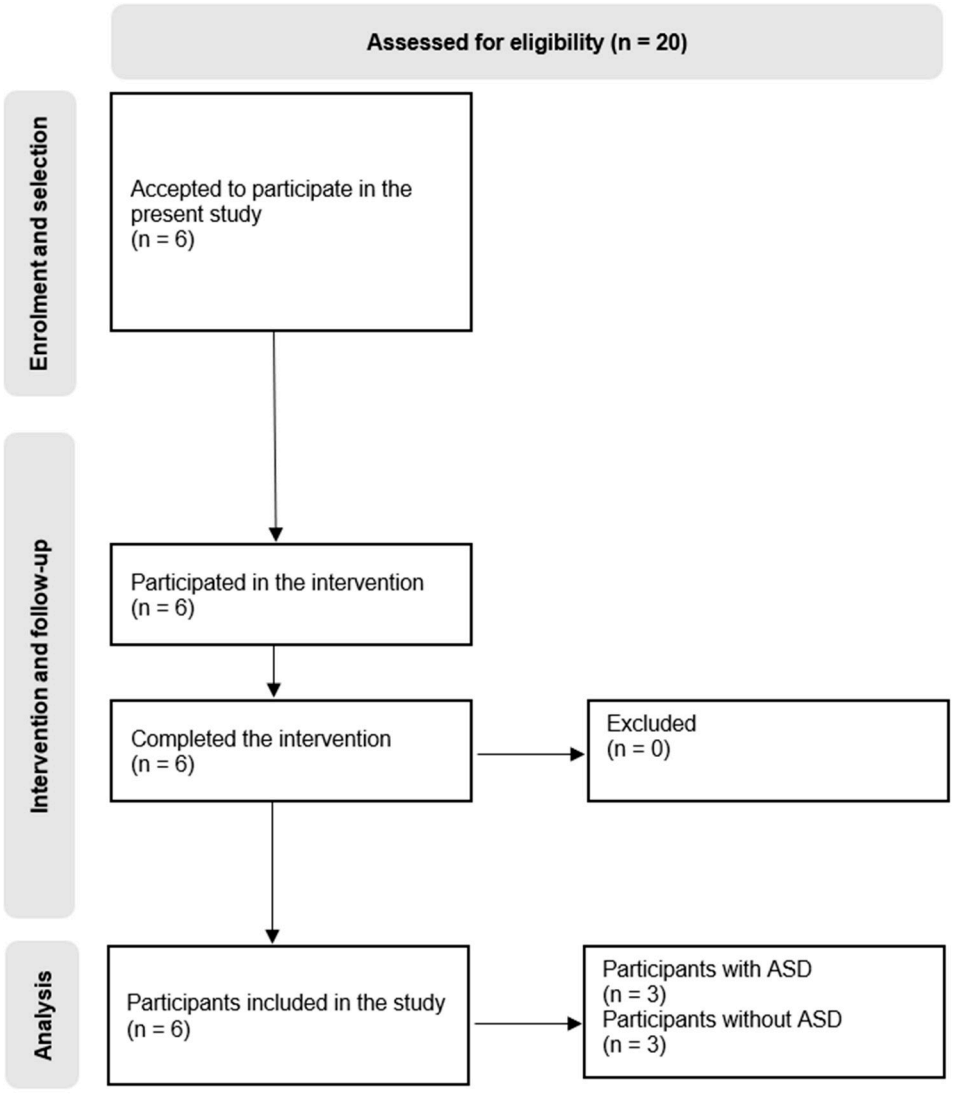

Figure 1. Participant flowchart.

2.2. Instruments

Objective methods used to assess motor skills generally fall into two categories: process assessments (which refer to how the skill is performed) and product assessments (which refer to the final outcome of the skill). Product-oriented assessments measure the result of the movement (e.g., the number of catches), such as the MCA Battery [30].

The MCA is a battery of quantitative tests consisting of six tests divided into three subscales: stability, locomotion, and manipulation. Each subscale is calculated from two objectively measured tests. All motor tests in the MCA are quantitative (product-oriented), without developmental (age) effects, and easy to perform, even with minimal practice. After determining the construct validity of the MCA for children and adolescents [61], normative values were established for ages 3 to 23 years [62].

The MCA includes three categories and six tests.

- Locomotion (10 m Shuttle Run; Standing Long Jump)
- Stability (Shifting platforms; Lateral Jumps)
- Object Manipulation (Throwing velocity; kicking velocity).

For various methodological reasons (e.g., intervention and material resources), the research team chose not to assess their ability to manipulate.

2.3. Intervention

During the baseline period, informed consent was obtained from the parents and baseline data were collected and assessed using the MCA Battery, providing a starting point to measure progress. The activities and objectives were explained to both the parents and the children. The first session of the project took place on 2 October, and it concluded on 27 May.

For 20 weeks, on Mondays and Wednesdays, from 6:00 P.M. to 6:45 P.M., 68 practical sessions were conducted; 3 motor skills assessment sessions and 2 gymnastics training meetings were held. The sessions were planned in a way that followed a logical and structured format, including an initial part, core part, and final cool-down section, maintaining this structure throughout the practical sessions.

The plan was designed to promote and develop the motor skills of children with ASD, in addition to providing behavioral, social, and emotional support, and encouraging autonomy and decision-making skills, among other goals. All of this was achieved through gymnastics practice.

2.3.1. Initial Phase

The initial warm-up phase, which lasted between the first 5 and 7 min of the session, involved the use of playful activities. These activities allowed each child to develop autonomous decision-making and power of choice, make discoveries, and seek solutions. This type of game helps participants improve their performance, engagement, and social integration as well as important components such as motor coordination laterality, among others.

Station-Based Exercise

- Objective: To work on locomotion, cardiovascular fitness, and strength.
- Description: Stations: Four different stations were set up:
    - Station 1: Climbing and descending stairs. The children must climb and descend a staircase (or low steps) for a set amount of time.

- Station 2: Jumping over sponges. Sponges are placed on the floor, and the children must repeatedly jump over them using both legs simultaneously.
- Station 3: Balance walking on benches. A bench or low beam is placed on the floor, and the children must walk on it while maintaining their balance.
- Station 4: Jumping through hoops. Hoops are placed on the floor, and the children must jump in and out of the hoops, either alternating feet or using both feet together.

- Instructions:
  - Divide the children into equal groups and assign each group to a station.
  - At the signal of a whistle or other command, the children begin performing the activity corresponding to their station for a set amount of time (e.g., 1 min).
  - After the time is up, for the given signal, the groups rotate to the next station in a clockwise direction.
  - Continue the rotation until each group has visited all the stations.

Animal Movements

- Objective: To develop strength and coordination.
- Description: Animal movements as part of the warm-up.
  - Bear Walk: With your hands and feet on the ground, lift your hips into the air and walk on all fours (hands and feet). Move forward and backward.
  - Crab Walk: Start by sitting on the floor. Place your hands flat behind you, with your fingers pointing outward or toward your hips. Bend your knees and place your feet flat on the floor with your belly facing up. Shifting your weight onto your hands and feet, lift your hips off the ground so that your body is supported in a position similar to a table. The torso should be as flat and as horizontal as possible to the floor. Move forward, backward, and sideways.
  - Rabbit Jump: Stand with both feet on the ground, raise your arms above your head, and perform small jumps forward. Keep your arms above your head throughout the exercise. The rabbit jumps can also be performed backward.

2.3.2. Core Phase

The following training plan was developed based on the guidelines from the book Coaching Youth Gymnastics [63], in collaboration with the USA Gymnastics. The principles and methods described in these sources were strictly followed to ensure a structured and effective approach for teaching gymnastics to young athletes, ensuring safe and appropriate progression at each stage of training. It consisted of two parts: the first part involved exercises performed on the floor, while the second part focused on trampoline jumps, such as tuck jumps, pike jumps, straddle jumps, half turns, full turns, sitting, and crawling.

2.3.3. Floor Exercise: Preparatory Skills

Preparatory skills for floor exercises are fundamental to the development of more advanced skills and help gymnasts build a solid foundation. These skills serve as intermediate steps that facilitate execution of complex movements and sequences. The following essential preparatory skills were applied:

- Bridge
- Forward Roll
- Backward Roll
- Cartwheel
- Handstand

For more information, see Appendix A.

2.3.4. Jumping Exercise: Preparatory Skills

The second part focused on trampoline jumps, such as tuck jumps, pike jumps, straddle jumps, half turns, full turns, seated jumps, and crawling jumps. Jumps and Landings: in trampoline gymnastics, mastering preparatory skills for jumps and landings is essential to ensure safe and effective execution. These skills will help gymnasts build the necessary foundation for performing advanced and complex movements in the future. The following essential preparatory skills were applied:

- Extension Jump
- Tuck Jump (or Squat Jump)
- Pike Jump (legs together): This is a movement where the child jumps and, while in the air, bends their body forward with legs extended and together, attempting to touch their feet with their hands.
- Straddle Pike Jump (legs apart): This is a movement that combines a pike jump with legs open, forming a "V" shape while the body bends forward.
- Half Turn (or 1/2 Turn): In trampoline gymnastics, this is a movement where the gymnast performs a jump and spins 180 degrees in the air before landing.
- Full Turn (1 Turn): In trampoline gymnastics, this is a movement where the gymnast performs a jump and spins 360 degrees in the air before landing.
- Stomach Drop (or Belly Drop): This is a movement in trampoline gymnastics, where the child jumps and lands on their stomach (belly down).
- Combined Jumps: To add variety and difficulty, practice combined jumps by linking two or three jumps in a sequence. Start with the same jump repeated, and then progress to different jumps in sequence. For example, a sequence could be a tuck jump followed by a pike jump. In trampoline gymnastics, combined jumps are an excellent way to increase the complexity and challenge of the training by linking two or three jumps in a smooth sequence.

For more information, see Appendix B.

After several weeks of basic jump training, it was decided to combine different jumps to create a short routine. This routine included tuck jumps, seated jumps, crawling jumps, standing jumps, and half turns. It is important to note that from session to session, there was a gradual increase in the difficulty of the proposed exercises, sometimes repeating the same exercise in the following session, but with imposed variations that made the previous movement more challenging.

2.3.5. Final Phase

In the final phase of the sessions, dedicated to cool-down, activities were carried out to gradually reduce the intensity of physical exercise and promote a state of relaxation and recovery in children. This phase, lasting approximately 2 to 3 min, included stretching and relaxation activities, focusing on different muscle groups worked during the session.

The stretches included gentle and controlled movements, such as stretching the arms, legs, and torso, and flexibility exercises, such as touching the toes, extending the arms above the head, and stretching the back muscles.

2.4. Statistical Analysis

Descriptive statistics, including the mean and standard deviation of the variables, were calculated. The normality of the data was checked using the Shapiro-Wilk test ($n < 50$). The Friedman test was used to compare and identify potential differences between the groups. To reduce Type I errors, multiple comparison tests incorporated the

Bonferroni correction, calculated as the alpha level divided by the number of tests [64]. Kendall's W effect size (appropriate for the Friedman test, which allows the comparison of two paired groups) was calculated using the reference values specified below: "small" effect ≥ 0.01, "medium" effect ≥ 0.3, and "large" effect ≥ 0.5 [65,66]. The significance level for rejecting the null hypothesis was set at 5%, and analyses were performed using IBM SPSS version 29.

3. Results

Table 1 presents the results of the tests conducted at three different time points (Time 1, Time 2, and Time 3) for the total sample (children with and without ASD). The tests included platform transitions, side jumps, shuttle runs, and horizontal jumps, aimed at evaluating progress in motor skills over time.

There appears to be an improvement in the platform transition test from Time 1 (4 ± 1.41 s) to Time 2 (4.83 ± 1.32 s) and Time 3, with the highest value (5.83 ± 1.60 s). Regarding the side jumps test, we can observe the same trend as in the platform transition test, i.e., the values increased from Time 1 (8.5 ± 3.20 repetitions) to Time 2 (9.17 ± 3.48 repetitions) and Time 3 (11.33 ± 4.27 repetitions). The result of the Shuttle Run test seems to have decreased from Time 1 (20.55 ± 4.69 s) to Time 2 (19.69 ± 3.64 s) and Time 3 (18.53 ± 2.32 s), which is a positive outcome. As for the horizontal jumps test, we observe the same trend as in the other tests, i.e., there seems to be an improvement from Time 1 (64.4 ± 22.59 cm) to Time 2 (65.38 ± 22.47 cm) and Time 3 (65.5 ± 21.10 cm). The results of the descriptive statistics seem to indicate improvements over time in all the tests performed.

Table 1. Presentation of test results for children across three assessment time points.

	Moment 1 (Pre-Intervention)		Moment 2 (Intermediate Moment)		Moment 3 (Post-Intervention)		Pairwise Comparisons (Moments) [a,b]
	Mean ± Standard Deviation	Median (Interquartile Range)	Mean ± Standard Deviation	Median (Interquartile Range)	Mean ± Standard Deviation	Median (Interquartile Range)	
Shuttle Run (s)	20.55 ± 4.69	19.85 (8)	19.69 ± 3.64	19.10 (8)	18.53 ± 2.32	18.53 (5)	[c]
Platform transfer (transfers)	4.00 ± 1.41	4.00 (2.5)	4.83 ± 1.32	5.00 (2.25)	5.83 ± 1.60	6.00 (3.25)	M1 ≠ M3 (t = −1.667; p = 0.012; w = 0.16)
Side Jumps (repetitions)	8.50 ± 3.20	8.00 (5)	9.17 ± 3.48	9.00 (7)	11.33 ± 4.27	11.50 (7)	M1 ≠ M3 (t = −1.417; p = 0.042; w = 0.14)
Standing long jump (cm)	64.40 ± 22.59	68.40 (40.35)	65.38 ± 22.47	71.75 (43.05)	65.50 ± 21.10	68.15 (21.10)	c

Note: a: Friedman; b: Bonferroni correction; c: There are no differences; t: test statistics; w: effect size.

No significant differences were found between the time points in the assessments of the 10 m Shuttle Run and Standing long jump tests ($p > 0.05$), despite the descriptive statistics indicating improvements in the tests. In contrast, significant differences were found between time points in the Shifting platforms test (pre-intervention ≠ post-intervention; Bonferroni correction: t = −1.667; p = 0.012; W = 0.16) and in the Lateral Jumps test (pre-intervention ≠ post-intervention; Bonferroni correction: t = −1.417; p = 0.042; W = 0.14). Table 2 presents the results of various tests performed at three distinct time points (Time 1, Time 2, and Time 3), considering only children without ASD.

There appears to be an improvement in the 10 m Shuttle Run from Time 1 (16.76 ± 0.81 s) to Time 2 (16.51 ± 0.59 s) but increased to Time 3 (16.56 ± 0.55 s), although still showing lower values than at Time 1. Regarding the Shifting platforms test, values

increased from Time 1 (5.00 ± 1.00 transfers) to Time 2 (6.00 ± 0.00 transitions) and then to Time 3 (7.00 ± 1.00 transitions). In relation to the Lateral Jumps test, we observe the same trend. Values increased from Time 1 (10.33 ± 3.05 repetitions) to Time 2 (11.66 ± 2.30 repetitions) and then to Time 3 (14.00 ± 2.64 repetitions). As for the Standing long jump test, the values decreased from Time 1 (86.00 ± 12.72 cm) to Time 2 (83.00 ± 7.21 cm) and again to Time 3 (82.10 ± 11.25 cm).

Table 2. Presentation of Test Results for Children without ASD Across Three Assessment Time Points.

	Moment 1 (Pre-Intervention)		**Moment 2 (Intermediate Moment)**		**Moment 3 (POST-intervention)**		**Pairwise Comparisons (Moments)** [a,b]
	Mean ± Standard Deviation	**Median (Interquartile Range)**	**Mean ± Standard Deviation**	**Median (Interquartile Range)**	**Mean ± Standard Deviation**	**Median (Interquartile Range)**	
Shuttle Run (s)	16.76 ± 0.81	16.4 (-)	16.51 ± 0.59	16.20 (-)	16.56 ± 0.55	16.26 (-)	c
Platform transfer (transfers)	5.00 ± 1.00	5.00 (-)	6.00 ± 0.00	6.00 (-)	7.00 ± 1.00	7 (-)	c
Side Jumps (repetitions)	10.33 ± 3.05	11.00 (-)	11.66 ± 2.30	13.00 (-)	14.00 ± 2.64	15 (-)	c
Standing long jump (cm)	86.00 ± 12.72	86.00 (-)	83.00 ± 7.21	81.00 (-)	82.10 ± 11.25	77 (-)	c

Note: a: Friedman; b: Bonferroni correction; c: There are no differences.

No significant differences were found between the time points in the assessments of the Shuttle Run, Shifting platforms, Lateral jumps, and Standing long jump tests ($p > 0.05$).

Table 3 presents the results of the various tests performed at three distinct time points (Time 1, Time 2, and Time 3), considering only the children diagnosed with ASD.

There appears to be an improvement in the 10 m Shuttle Run test at each time point: from Time 1 (24.33 ± 2.51 s) to Time 2 (22.87 ± 1.62 s) and subsequently to Time 3 (20.50 ± 1.25 s). Regarding the Shifting platforms test, we observe the same trend. The values increased from Time 1 (3.00 ± 1.00 transfers) to Time 2 (3.66 ± 0.57 transitions), and then to Time 3 (4.66 ± 1.15 transitions). In relation to the Lateral Jumps test, the values remained the same from Time 1 (6.66 ± 2.51 repetitions) to Time 2 (6.66 ± 2.51 repetitions) but increased for Time 3 (8.66 ± 2.51 repetitions). As for the Standing long jump test, the values increased from Time 1 (46.70 ± 14.46 cm) to Time 2 (47.76 ± 16.73 cm) but then decreased again at Time 3 (47.23 ± 10.18 cm), although still showing higher values than at Time 1. Despite the specific variations in each test, the descriptive statistical analysis of the data reveals a general trend of improvement in the participants' motor skills across the three assessment time points.

Table 3. Presentation of test results for children with ASD Across the three assessment time points.

	Moment 1 (Pre-Intervention)		**Moment 2 (Intermediate Moment)**		**Moment 3 (Post-Intervention)**		**Pairwise Comparisons (Moments)** [a,b]
	Mean ± Standard Deviation	**Median (Interquartile Range)**	**Mean ± Standard Deviation**	**Median (Interquartile Range)**	**Mean ± Standard Deviation**	**Median (Interquartile Range)**	
Shuttle Run (s)	24.33 ± 2.51	24.00 (-)	22.87 ± 1.62	23.60 (-)	20.50 ± 1.25	20.40 (-)	M1 ≠ M3 (t = −2.00; p = 0.043; w = 0.33)

Platform transfer (transfers)	3.00 ± 1.00	3.00 (-)	3.66 ± 0.57	4.00 (-)	4.66 ± 1.15	4 (-)	c
Side Jumps (repetitions)	6.66 ± 2.51	7.00 (-)	6.66 ± 2.51	7.00 (-)	8.66 ± 2.51	10 (-)	c
Standing long jump (cm)	46.70 ± 14.46	47.76 (-)	47.76 ± 16.73	42.50 (-)	47.23 ± 10.18	51 (-)	c

Note: a: Friedman; b: Bonferroni correction; c: There are no differences; t: test statistics; w: effect size.

No significant differences were found between the time points in the assessments of the Shifting platforms, Lateral jumps, and Standing long jump tests ($p > 0.05$). Significant differences were found only between the time points in the 10 m Shuttle Run test (pre-intervention ≠ post-intervention; Bonferroni correction: $t = -2.00$; $p = 0.043$; $w = 0.33$).

4. Discussion

The overall objective of this program was to investigate the effects of an intervention program based on gymnastics, specifically trampolining, on the motor competence of children with ASD.

Regarding the analysis of the total sample (Table 1), there appeared to be general improvements in the various tests conducted. However, when the total sample was analyzed, significant improvements were observed only in the Platform Transition and Side Jumps tests. These results suggest that the intervention was effective in these specific areas, leading to significantly better performance over time.

The current results are consistent with previous research, which confirms that physical activity intervention programs provide evidence that can improve motor skill development in children [67,68]. In studies by Goodway and Branta [58] and Apache [57], following the completion of a physical activity intervention program, the authors found statistically significant differences in children with disabilities who participated in a motor intervention program, with these children showing significant improvements in locomotor skills and object control.

Considering the participants without ASD, the intervention appeared to improve, although not significantly, the Platform transfer and side jump test, which could represent improvements in strength, coordination, and agility. Performance in the Shuttle Run improved slightly, although not significantly, but was not consistent post-intervention. However, the distance in the Standing long jump test decreased slightly over time (also non-significantly), suggesting that the intervention did not have a positive impact on lower limb strength. Adjustments to the program may be necessary to optimize performance in all skills assessed.

Regarding the analysis of the group of children with ASD (Table 3), there appeared to be a general trend of improvement in motor skills across the three time points. However, only the Shuttle Run test showed a significant difference. This can be interpreted as a more noticeable improvement in terms of speed and agility, while the other tests (Platform Transition, Side Jumps, and Horizontal Jumps) showed improvements, but these were not statistically significant.

The results of the present study are consistent with those described in the literature [59,60], suggesting that significant gains in motor development can be achieved as a result of structured motor skills intervention. The results of this study were consistent with those reported in the literature.

The significant improvements in the different tests are related to the frequency and structure of the training applied during the intervention. According to the Development and Competence Program for Age Groups from the Portuguese Gymnastics Federation,

it is essential that training be structured in a safe and systematic manner, focusing on the quality of execution and health of the children, before increasing the difficulty of exercises. The program recommends that for children aged 5 or 6 years, training sessions should be conducted 1 to 2 times per week, with a duration of 1.5 h, to promote adequate movement regulation and create the necessary prerequisites for gymnastics practice. If the frequency or duration of the training does not follow these guidelines, children's progress may be affected, particularly in skills that require a lot of practice, such as horizontal and lateral jumps. Furthermore, the selection of exercises is important; if jumps are not prioritized or worked on consistently, it could explain the lack of improvement.

It is important to highlight that children's adherence to the training program was, on average, 65% in terms of session attendance. The adherence rate varied among participants and had a significant impact on the overall effectiveness of the program. This adherence, which was lower than anticipated, can be explained by the inherent challenges of family life, which at times were reported as reasons for some absences from specific sessions.

The significance of the results of this project for the population, especially for children with ASD, is profound in terms of their quality of life. The continuous practice of physical activity, as evidenced by previous studies, is crucial for the development and maintenance of motor skills in this population. Studies, such as Healy et al. (2018) [6], have highlighted that regular physical activity contributes to the improvement of motor skills and overall well-being in children with ASD. The use of tools, such as the Motor Competence Battery, proved to be effective in the quantitative assessment of motor skills without presenting limitations due to development. Thus, physical exercise not only promotes motor development but also provides additional benefits such as improvement in coordination, balance, and sensory integration skills. Furthermore, the literature, including research by Pitetti et al. [69], suggests that physical exercise is an effective means of preventing and mitigating motor problems in the general population, and may have similar effects on children with ASD. Therefore, the implementation of structured and regular physical activity programs is essential to promote the quality of life of children with ASD, helping them achieve a higher level of autonomy and improve their motor and social skills, contributing to more balanced and integrated development.

Studies have shown that regular physical activity has a positive impact on the motor skills of children with ASD due to the neurological and physiological mechanisms involved [68]. The neuroplasticity stimulated by physical activity increases the levels of the Brain-Derived Neurotrophic Factor in children with ASD, promoting the growth of neural connections. This facilitates motor learning and execution of coordinated movements [70]. In addition, regular physical activity improves sensory integration; helps to process visual, tactile, vestibular, and proprioceptive information; and promotes balance, body awareness, and motor coordination in participants with ASD [68,71]. Another important mechanism is improved neuromuscular communication, which increases the efficiency and effectiveness of signal transmission between the brain and muscles, thereby promoting faster and more precise motor responses in children with autism. Physical fitness, such as muscle strength and endurance, is also developed through regular physical activity, improved posture, and the ability to perform more complex motor tasks in individuals with autism [5].

Limitations and Future Recommendations

Although this study seems to have found positive effects of a trampoline-based training program for children with ASD, several limitations were observed. The variation in the individual abilities of the children with ASD may have influenced the results, as it made it difficult to establish a uniform prescription and implementation of the program.

Additionally, the duration of the study may not have been sufficient to observe significant changes in all areas of motor development. The adherence of the children to the training program also varied, which impacted the program's effectiveness. Finally, the absence of a control group limited the ability to directly attribute the observed changes to trampoline intervention.

The exploration of different sports modalities for children with ASD, as well as the development of specific interventions aimed at promoting the motor skills of these children, could be considered as future recommendations. For future studies, it is recommended to expand the sample to include other age groups, establish a control group for the comparison of effects, and extend the duration of the study. Furthermore, personalizing the training program, assessing multiple dimensions of development, and using standardized assessment tools are essential for obtaining a more comprehensive understanding of the program's benefits. It would also be interesting to include other modalities with different motor stimuli in future studies.

In addition to highlighting the theoretical importance of the study's results, it is crucial to discuss their practical implications for health professionals, educators, and the families of individuals with ASD. This may include how the results of the study can influence clinical practices, therapeutic interventions, or public policies regarding the promotion of physical activity.

5. Conclusions

Significant improvements were seen in some motor skills, both in children with ASD and neurotypical children. Considering the overall sample, although significant differences were found between the moments in the Platform Transposition test and the Side Jump test, all tests showed improvements. In the case of children with ASD, improvements were also seen in all tests, although only significant in the Shuttle Run test. This finding suggests that the intervention had a positive impact on coordination, balance, and motor control skills, which are often difficult for children with ASD.

Considering all the considerations made in this study, we can draw a well-founded conclusion that the continued practice of trampoline gymnastics could have a significant positive impact on the overall development and well-being of children with ASD. Thus, further research on physical activity, complemented by similar studies, will undoubtedly make a valuable contribution to improving the quality of life of these children.

Author Contributions: Conceptualization, G.Q., M.J. and R.A.; methodology, G.Q., M.J., R.M. and R.A.; software, M.J. and R.A.; validation, M.J. and R.A.; formal analysis, G.Q., M.J. and R.A.; investigation, G.Q., M.J. and R.A.; resources, G.Q., M.J. and R.A.; data curation, G.Q., M.J. and R.A.; writing—original draft preparation, G.Q.; writing—review and editing, G.Q., M.J. and R.A.; visualization, G.Q., M.J., N.A., D.M., R.M., S.D., T.M. and R.A.; supervision, M.J., N.A., D.M., R.M., S.D., T.M. and R.A.; project administration, G.Q., M.J., N.A., D.M., R.M., S.D., T.M. and R.A.; funding acquisition, M.J., N.A., D.M., R.M., S.D. and R.A. All authors have read and agreed to the published version of the manuscript.

Funding: This work was funded by National Funds by FCT—Foundation for Science and Technology under the following project UIDB/04045/2020 (https://doi.org/10.54499/UIDB/04045/2020).

Institutional Review Board Statement: The study was conducted in accordance with the principles outlined in the 1964 Helsinki Declaration and its subsequent revisions or comparable ethical standards. This study was approved on the 27 March 2024 by the Ethics Committee of the Polytechnic University of Leiria (approval no. 53/2024).

Informed Consent Statement: Informed consent was obtained from all the subjects involved in the study. Written informed consent was obtained from the patients (s) to publish this paper.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Ground Exercises:
Bridge

- Preparation and Safe Environment
  - Adequate space: First, make sure the space is free of obstacles and well-padded.
  - Explanation of the activity: tell the child that they are going to learn how to do a "bridge" and explain that this involves lifting the body off the ground, supporting yourself on your hands and feet, with your belly facing up.
- Demonstration and Visual Explanation
  - Demonstration: Show the child how to make a bridge, starting by lying on their back and then pushing themselves up with their hands and feet.
- Breaking the Movement into Small Steps
  - Initial Position: Ask the child to lie on their back with their knees bent and feet flat on the ground. Their hands should be next to their head, fingers pointing toward the shoulders. Explain: "We lie on our back with our knees bent and hands beside our head".
  - Pushing Up: Instruct the child to press their feet and hands against the floor to lift their hips and upper body, forming the bridge. Help the child to push up, if necessary, while you say: "Now we push the floor with our feet and hands to lift our belly".
  - Holding the Position: ask the child to hold the position for a few seconds, encouraging them to breathe calmly and maintain balance ("hold the position, like a strong bridge").
- Repetition and Positive Reinforcement
  - Practice: repeating the movement several times will make it easier and easier for the child.
  - Praise and motivation: provide feedback and praise such as: "Great job, your bridge is getting better and better!"
- Adaptations According to Needs
  - Physical support: When the child has difficulty pushing up on their own, provide gentle physical support to assist with the lift.
  - Breaking down the movement: When necessary, first practice the push with just the hips before integrating the use of the hands.
- Finishing and Feedback
  - Celebrating achievements: At the end of the session, celebrate the child's progress, whether they were able to complete the bridge independently or with assistance.
  - Reflection: ask the child how they felt about doing the bridge and if they were ready to try something new in the next session.

Appendix B

Jumping Exercises
Extension Jump

- Preparation and Safe Environment
  - Adequate space: make sure the trampoline is in good condition and that the area around it is free of obstacles.
  - Explanation of the activity: explain that you are going to learn how to do an extension jump, where the aim is to jump and stretch your body while you are in the air.
- Demonstration and Visual Explanation
  - Demonstration: Show how to perform the extension jump, emphasizing the beginning, middle, and end of the movement and doing it slowly so that the child can observe.
- Breaking the Movement into Small Steps
  - Initial Position on the Trampoline: Standing position: ask the child to stand on the trampoline with their feet shoulder-width apart and arms by their sides. Instruction: "We stand on the trampoline with our feet together and arms by our sides".
  - Preparing for the Jump: Squatting: explain to the child how to squat slightly to gain momentum, preparing to jump. Instruction: "We squat a little, as if we want to prepare for a big jump".
  - Performing the Extension Jump: Push and stretch: guide the child to push the trampoline with force, stretching the legs and arms while in the air, keeping the body extended and straight. Instruction: "Jump and stretch your body in the air, with your legs and arms extended like a star".
  - Landing: Controlled landing: teach the child to bend their knees slightly when landing to absorb the impact and maintain balance. Instruction: "When landing, we bend our knees a little to stay balanced."
- Repetition and Positive Reinforcement
  - Practice: repeat the jump several times, adjusting the support as needed to help the child improve their technique.
  - Praise and motivation: offer praise and positive reinforcement, such as: "Excellent jump! You're stretching your body really well!" and use simple rewards to encourage the child.
- Adaptations According to Needs
  - Physical support: When the child has difficulties, provide gentle physical support, such as helping to push the legs or guide the body to improve the extension.
  - Use of equipment: If necessary, use accessories such as guidance bands to help the child visualize and practice the correct extension.
- Finishing and Feedback
  - Celebrating achievements: At the end of the session, celebrate the child's progress, regardless of the level achieved.
  - Reflection: ask the child how they felt about doing the extension jump and if there was anything they would like to try or improve in the next session.

References

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed.; American Psychiatric Association: Washington, DC, USA, 2022.
2. Gargot, T. Sensory and Motor Difficulties in Autism. *Eur. Psychiatry* **2022**, *65*, S64. https://doi.org/10.1192/j.eurpsy.2022.208.

3. Wang, L.A.L.; Petrulla, V.; Zampella, C.J.; Waller, R.; Schultz, R.T. Gross Motor Impairment and Its Relation to Social Skills in Autism Spectrum Disorder: A Systematic Review and Two Meta-Analyses. *Psychol. Bull.* **2022**, *148*, 273–300. https://doi.org/10.1037/bul0000358.
4. Hamm, J.; Yun, J. Influence of Physical Activity on the Health-Related Quality of Life of Young Adults with and without Autism Spectrum Disorder. *Disabil. Rehabil.* **2019**, *41*, 763–769. https://doi.org/10.1080/09638288.2017.1408708.
5. Shahane, V.; Kilyk, A.; Srinivasan, S.M. Effects of Physical Activity and Exercise-Based Interventions in Young Adults with Autism Spectrum Disorder: A Systematic Review. *Autism* **2024**, *28*, 276–300. https://doi.org/10.1177/13623613231169058.
6. Healy, S.; Nacario, A.; Braithwaite, R.E.; Hopper, C. The Effect of Physical Activity Interventions on Youth with Autism Spectrum Disorder: A Meta-Analysis. *Autism Res.* **2018**, *11*, 818–833. https://doi.org/10.1002/aur.1955.
7. Teh, E.J.; Vijayakumar, R.; Tan, T.X.J.; Yap, M.J. Effects of Physical Exercise Interventions on Stereotyped Motor Behaviours in Children with ASD: A Meta-Analysis. *J. Autism Dev. Disord.* **2022**, *52*, 2934–2957. https://doi.org/10.1007/s10803-021-05152-z.
8. Lourenço, C.; Esteves, D.; Corredeira, R.; Seabra, A. The Effect of a Trampoline-Based Training Program on the Muscle Strength of the Inferior Limbs and Motor Proficiency in Children with Autism Spectrum Disorders. *J. Phys. Educ. Sport.* **2015**, *15*, 592. https://doi.org/10.7752/jpes.2015.03089.
9. Sulaiman, M.; Baig, M.; Memon, S.; Ashraf, N.; Butt, P.; Afzal, K.; Iqbal, R. Effects of Trampoline Exercises in Children with Developmental Coordination Disorder: A Randomized Controlled Trial. *Phys. Med. Rehabil. Kurortmed.* **2022**, *32*, 279–284. https://doi.org/10.1055/a-1755-8655.
10. Matson, J.L.; Rivet, T.T. Characteristics of Challenging Behaviours in Adults with Autistic Disorder, PDD-NOS, and Intellectual Disability. *J. Intellect. Dev. Disabil.* **2008**, *33*, 323–329. https://doi.org/10.1080/13668250802492600.
11. Hus, Y.; Segal, O. Challenges Surrounding the Diagnosis of Autism in Children. *Neuropsychiatr. Dis. Treat.* **2021**, *17*, 3509–3529. https://doi.org/10.2147/NDT.S282569.
12. Ozonoff, S.; Young, G.S.; Goldring, S.; Greiss-Hess, L.; Herrera, A.M.; Steele, J.; Macari, S.; Hepburn, S.; Rogers, S.J. Gross Motor Development, Movement Abnormalities, and Early Identification of Autism. *J. Autism Dev. Disord.* **2008**, *38*, 644–656. https://doi.org/10.1007/s10803-007-0430-0.
13. Pan, C.-Y.; Frey, G.C. Physical Activity Patterns in Youth with Autism Spectrum Disorders. *J. Autism Dev. Disord.* **2006**, *36*, 597–606. https://doi.org/10.1007/s10803-006-0101-6.
14. Fournier, K.A.; Hass, C.J.; Naik, S.K.; Lodha, N.; Cauraugh, J.H. Motor Coordination in Autism Spectrum Disorders: A Synthesis and Meta-Analysis. *J. Autism Dev. Disord.* **2010**, *40*, 1227–1240. https://doi.org/10.1007/s10803-010-0981-3.
15. Li, M.; Francis, E.; Hinkle, S.N.; Ajjarapu, A.S.; Zhang, C. Preconception and Prenatal Nutrition and Neurodevelopmental Disorders: A Systematic Review and Meta-Analysis. *Nutrients* **2019**, *11*, 1628. https://doi.org/10.3390/nu11071628.
16. Tao, Q.; Shen, Y.; Li, Y.; Luo, H.; Yuan, M.; Gan, J. Prenatal Exposure to Antibiotics and Risk of Neurodevelopmental Disorders in Offspring: A Systematic Review and Meta-Analysis. *Front. Neurol.* **2022**, *13*, 1045865. https://doi.org/10.3389/fneur.2022.1045865.
17. Hondt, E.D.; Deforche, B.; De Bourdeaudhuij, I.; Lenoir, M. Relationship between Motor Skill and Body Mass Index in 5- to 10-Year-Old Children. *Adapt. Phys. Act. Q.* **2009**, *26*, 21–37. https://doi.org/10.1123/apaq.26.1.21.
18. Stodden, D.F.; Goodway, J.D.; Langendorfer, S.J.; Roberton, M.A.; Rudisill, M.E.; Garcia, C.; Garcia, L.E. A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest* **2008**, *60*, 290–306. https://doi.org/10.1080/00336297.2008.10483582.
19. Thomas, S.; Barnett, L.M.; Papadopoulos, N.; Lander, N.; McGillivray, J.; Rinehart, N. How Do Physical Activity and Sedentary Behaviour Affect Motor Competence in Children with Autism Spectrum Disorder Compared to Typically Developing Children: A Pilot Study. *J. Autism Dev. Disord.* **2022**, *52*, 3443–3455. https://doi.org/10.1007/s10803-021-05205-3.
20. Robinson, L.E.; Stodden, D.F.; Barnett, L.M.; Lopes, V.P.; Logan, S.W.; Rodrigues, L.P.; D'Hondt, E. Motor Competence and Its Effect on Positive Developmental Trajectories of Health. *Sports Med.* **2015**, *45*, 1273–1284. https://doi.org/10.1007/s40279-015-0351-6.
21. Fransen, J.; D'Hondt, E.; Bourgois, J.; Vaeyens, R.; Philippaerts, R.M.; Lenoir, M. Motor Competence Assessment in Children: Convergent and Discriminant Validity between the BOT-2 Short Form and KTK Testing Batteries. *Res. Dev. Disabil.* **2014**, *35*, 1375–1383. https://doi.org/10.1016/j.ridd.2014.03.011.
22. Park, J.; Jeong, J. Dribble Accuracy and Arm Coordination Pattern According to Motor Expertise and Tempo. *Int. J. Environ. Res. Public Health* **2023**, *20*, 5788. https://doi.org/10.3390/ijerph20105788.
23. Morasso, P. A Vexing Question in Motor Control: The Degrees of Freedom Problem. *Front. Bioeng. Biotechnol.* **2022**, *9*, 783501. https://doi.org/10.3389/fbioe.2021.783501.

24. Bolger, L.E.; Bolger, L.A.; O'Neill, C.; Coughlan, E.; O'Brien, W.; Lacey, S.; Burns, C.; Bardid, F. Global Levels of Fundamental Motor Skills in Children: A Systematic Review. *J. Sports Sci.* **2021**, *39*, 717–753. https://doi.org/10.1080/02640414.2020.1841405.
25. Carcamo-Oyarzun, J.; Herrmann, C. Validez de Constructo de La Batería MOBAK Para La Evaluación de Las Competencias Motrices Básicas En Escolares de Educación Primaria. *Rev. Española Pedagog.* **2023**, *78*, 291–308. https://doi.org/10.22550/REP78-2-2020-03.
26. Talbott, M.R.; Young, G.S.; Munson, J.; Estes, A.; Vismara, L.A.; Rogers, S.J. The Developmental Sequence and Relations Between Gesture and Spoken Language in Toddlers With Autism Spectrum Disorder. *Child. Dev.* **2020**, *91*, 743–753. https://doi.org/10.1111/cdev.13203.
27. Landa, R.J.; Gross, A.L.; Stuart, E.A.; Faherty, A. Developmental Trajectories in Children with and without Autism Spectrum Disorders: The First 3 Years. *Child. Dev.* **2013**, *84*, 429–442. https://doi.org/10.1111/j.1467-8624.2012.01870.x.
28. Landys, M.M.; Ramenofsky, M.; Wingfield, J.C. Actions of Glucocorticoids at a Seasonal Baseline as Compared to Stress-Related Levels in the Regulation of Periodic Life Processes. *Gen. Comp. Endocrinol.* **2006**, *148*, 132–149. https://doi.org/10.1016/j.ygcen.2006.02.013.
29. Strittmatter, A.; Sunde, U.; Zegners, D. Life Cycle Patterns of Cognitive Performance over the Long Run. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 27255–27261. https://doi.org/10.1073/pnas.2006653117.
30. Bardid, F.; Vannozzi, G.; Logan, S.W.; Hardy, L.L.; Barnett, L.M. A Hitchhiker's Guide to Assessing Young People's Motor Competence: Deciding What Method to Use. *J. Sci. Med. Sport* **2019**, *22*, 311–318. https://doi.org/10.1016/j.jsams.2018.08.007.
31. Wolff, S.B.E.; Ko, R.; Ölveczky, B.P. Distinct Roles for Motor Cortical and Thalamic Inputs to Striatum during Motor Skill Learning and Execution. *Sci. Adv.* **2022**, *8*, eabk0231. https://doi.org/10.1126/sciadv.abk0231.
32. MacDonald, M.; Lord, C.; Ulrich, D.A. The Relationship of Motor Skills and Social Communicative Skills in School-Aged Children with Autism Spectrum Disorder. *Adapt. Phys. Act. Q.* **2013**, *30*, 271–282. https://doi.org/10.1123/apaq.30.3.271.
33. Hussain, A. Growth, Development and Maturation. *SSRN Electron. J.* **2021**. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3850708 (accessed on 20 December 2024).
34. Venetsanou, F.; Kambas, A. Environmental Factors Affecting Preschoolers' Motor Development. *Early Child. Educ. J.* **2010**, *37*, 319–327. https://doi.org/10.1007/s10643-009-0350-z.
35. Hestbaek, L.; Andersen, S.T.; Skovgaard, T.; Olesen, L.G.; Elmose, M.; Bleses, D.; Andersen, S.C.; Lauridsen, H.H. Influence of Motor Skills Training on Children's Development Evaluated in the Motor Skills in PreSchool (MiPS) Study-DK: Study Protocol for a Randomized Controlled Trial, Nested in a Cohort Study. *Trials* **2017**, *18*, 400. https://doi.org/10.1186/s13063-017-2143-9.
36. Bhat, A.N.; Landa, R.J.; Galloway, J.C. Current Perspectives on Motor Functioning in Infants, Children, and Adults with Autism Spectrum Disorders. *Phys. Ther.* **2011**, *91*, 1116–1129. https://doi.org/10.2522/ptj.20100294.
37. MacDonald, M.; Lord, C.; Ulrich, D.A. Motor Skills and Calibrated Autism Severity in Young Children with Autism Spectrum Disorder. *Adapt. Phys. Act. Q.* **2014**, *31*, 95–105. https://doi.org/10.1123/apaq.2013-0068.
38. Kindregan, D.; Gallagher, L.; Gormley, J. Gait Deviations in Children with Autism Spectrum Disorders: A Review. *Autism Res. Treat.* **2015**, *2015*, 741480. https://doi.org/10.1155/2015/741480.
39. Caspersen, C.J.; Powell, K.E.; Christenson, G.M. Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research. *Public Health Rep.* **1985**, *100*, 126–131.
40. Bartlo, P.; Klein, P.J. Physical Activity Benefits and Needs in Adults with Intellectual Disabilities: Systematic Review of the Literature. *Am. J. Intellect. Dev. Disabil.* **2011**, *116*, 220–232. https://doi.org/10.1352/1944-7558-116.3.220.
41. Calders, P.; Elmahgoub, S.; Roman de Mettelinge, T.; Vandenbroeck, C.; Dewandele, I.; Rombaut, L.; Vandevelde, A.; Cambier, D. Effect of Combined Exercise Training on Physical and Metabolic Fitness in Adults with Intellectual Disability: A Controlled Trial. *Clin. Rehabil.* **2011**, *25*, 1097–1108. https://doi.org/10.1177/0269215511407221.
42. Apolone, G.; Mosconi, P. Techniques for Assessing the Quality of Life with a Particular Emphasis on Physical Exercise. In *Role of Physical Exercise in Preventing Disease and Improving the Quality of Life*; Stocchi, V., De Feo, P., Hood, D.A., Eds.; Springer Milan: Milano, Italy, 2007; pp. 183–190, ISBN 978-88-470-0376-7.
43. Jacinto, M.; Antunes, R.; Monteiro, D.; Rodrigues, F.; Amaro, N.; Campos, M.J.; Ferreira, J.P.; Matos, R. Examining the Effects of a 24-Week Exercise Program on Functional Capacity, Cognitive Capacity, and Quality of Life in Individuals With Intellectual and Developmental Disabilities. *Adapt. Phys. Act. Q.* **2024**, *1*, 1–19. https://doi.org/10.1123/apaq.2024-0085.
44. Dhanasekara, C.S.; Ancona, D.; Cortes, L.; Hu, A.; Rimu, A.H.; Robohm-Leavitt, C.; Payne, D.; Wakefield, S.M.; Mastergeorge, A.M.; Kahathuduwa, C.N. Association Between Autism Spectrum Disorders and Cardiometabolic Diseases: A Systematic Review and Meta-Analysis. *JAMA Pediatr.* **2023**, *177*, 248–257. https://doi.org/10.1001/jamapediatrics.2022.5629.

45. Huang, J.; Du, C.; Liu, J.; Tan, G. Meta-Analysis on Intervention Effects of Physical Activities on Children and Adolescents with Autism. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1950. https://doi.org/10.3390/ijerph17061950.
46. Bremer, E.; Crozier, M.; Lloyd, M. A Systematic Review of the Behavioural Outcomes Following Exercise Interventions for Children and Youth with Autism Spectrum Disorder. *Autism* **2016**, *20*, 899–915. https://doi.org/10.1177/1362361315616002.
47. Alipour, V.; Shabani, R.; Zarrindast, M.-R.; Rahmani-Nia, F.; Nasehi, M. Treadmill Exercise Improves Stereotypical Behaviors in Autistic Rats: Treadmill Exercise Improves ASD. *Galen. Med. J.* **2022**, *11*, e1990. https://doi.org/10.31661/gmj.v11i.1990.
48. Jackson, S.L.J.; Abel, E.A.; Reimer, S.; McPartland, J.C. Brief Report: A Specialized Fitness Program for Individuals with Autism Spectrum Disorder Benefits Physical, Behavioral, and Emotional Outcomes. *J. Autism Dev. Disord.* **2024**, *54*, 2402–2410. https://doi.org/10.1007/s10803-022-05646-4.
49. Batey, C.A.; Missiuna, C.A.; Timmons, B.W.; Hay, J.A.; Faught, B.E.; Cairney, J. Self-Efficacy toward Physical Activity and the Physical Activity Behavior of Children with and without Developmental Coordination Disorder. *Hum. Mov. Sci.* **2014**, *36*, 258–271. https://doi.org/10.1016/j.humov.2013.10.003.
50. Dillon, S.R.; Adams, D.; Goudy, L.; Bittner, M.; McNamara, S. Evaluating Exercise as Evidence-Based Practice for Individuals with Autism Spectrum Disorder. *Front. Public Health* **2016**, *4*, 290. https://doi.org/10.3389/fpubh.2016.00290.
51. Gregor, S.; Bruni, N.; Grkinic, P.; Schwartz, L.; McDonald, A.; Thille, P.; Gabison, S.; Gibson, B.E.; Jachyra, P. Parents' Perspectives of Physical Activity Participation among Canadian Adolescents with Autism Spectrum Disorder. *Res. Autism Spectr. Disord.* **2018**, *48*, 53–62. https://doi.org/10.1016/j.rasd.2018.01.007.
52. Ng, R.; Bellugi, U.; Trauner, D. Social Functioning Mediates ADHD Symptomatology and Mental Health Functioning in Neurotypical Children versus Children with Autism Spectrum Disorder or Williams Syndrome (P3.312). *Neurology* **2018**, *90*, P3.312. https://doi.org/10.1212/WNL.90.15_supplement.P3.312.
53. Liu, Y.; Wang, L.; Xie, S.; Pan, S.; Zhao, J.; Zou, M.; Sun, C. Attention Deficit/Hyperactivity Disorder Symptoms Impair Adaptive and Social Function in Children With Autism Spectrum Disorder. *Front. Psychiatry* **2021**, *12*, 654485. https://doi.org/10.3389/fpsyt.2021.654485.
54. Choi, J.; Lee, M.; Lee, J.; Kang, D.; Choi, J.-Y. Correlates Associated with Participation in Physical Activity among Adults: A Systematic Review of Reviews and Update. *BMC Public Health* **2017**, *17*, 356. https://doi.org/10.1186/s12889-017-4255-2.
55. Ketcheson, L.; Hauck, J.L.; Ulrich, D. The Levels of Physical Activity and Motor Skills in Young Children with and without Autism Spectrum Disorder, Aged 2–5 Years. *Autism* **2018**, *22*, 414–423. https://doi.org/10.1177/1362361316683889.
56. Lang, R.; Koegel, L.K.; Ashbaugh, K.; Regester, A.; Ence, W.; Smith, W. Physical Exercise and Individuals with Autism Spectrum Disorders: A Systematic Review. *Res. Autism Spectr. Disord.* **2010**, *4*, 565–576. https://doi.org/10.1016/j.rasd.2010.01.006.
57. Apache, R.R.G. Activity-Based Intervention in Motor Skill Development. *Percept. Mot. Ski.* **2005**, *100*, 1011–1020. https://doi.org/10.2466/pms.100.3c.1011-1020.
58. Branta, C. Influence of a Motor Skill Intervention on Fundamental Motor Skill Development of Disadvantaged Preschool Children. *Res. Q. Exerc. Sport* **2003**, *74*, 36–46. https://doi.org/10.1080/02701367.2003.10609062.
59. Connor-Kuntz, F.J.; Dummer, G.M. Teaching across the Curriculum: Language-Enriched Physical Education for Preschool Children. *Adapt. Phys. Act. Q.* **1996**, *13*, 302–315. https://doi.org/10.1123/apaq.13.3.302.
60. Hamilton, M.; Goodway, J.; Haubenstricker, J. Parent-Assisted Instruction in a Motor Skill Program for At-Risk Preschool Children. *Adapt. Phys. Act. Q.* **1999**, *16*, 415–426. https://doi.org/10.1123/apaq.16.4.415.
61. Luz, C.; Rodrigues, L.P.; Almeida, G.; Cordovil, R. Development and Validation of a Model of Motor Competence in Children and Adolescents. *J. Sci. Med. Sport* **2016**, *19*, 568–572. https://doi.org/10.1016/j.jsams.2015.07.005.
62. Rodrigues, L.P.; Luz, C.; Cordovil, R.; Bezerra, P.; Silva, B.; Camões, M.; Lima, R. Normative Values of the Motor Competence Assessment (MCA) from 3 to 23 Years of Age. *J. Sci. Med. Sport* **2019**, *22*, 1038–1043. https://doi.org/10.1016/j.jsams.2019.05.009.
63. USA Gymnastics. *Coaching Youth Gymnastics*, 1st ed.; Human Kinetics: Champaign, IL, USA, 2011; ISBN 978-0-7360-8403-1.
64. Ho, R. *Handbook of Univariate and Multivariate Data Analysis with IBM SPSS*; CRC Press: Boca Raton, FL, USA, 2014; ISBN 978-1-4398-9022-6.
65. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed.; Routledge: New York, NY, USA, 1988; ISBN 978-0-203-77158-7.
66. Fritz, C.O.; Morris, P.E.; Richler, J.J. Effect Size Estimates: Current Use, Calculations, and Interpretation. *J. Exp. Psychol. Gen.* **2012**, *141*, 2–18. https://doi.org/10.1037/a0024338.
67. Van Capelle, A.; Broderick, C.R.; van Doorn, N.; Ward, R.E.; Parmenter, B.J. Interventions to Improve Fundamental Motor Skills in Pre-School Aged Children: A Systematic Review and Meta-Analysis. *J. Sci. Med. Sport* **2017**, *20*, 658–666. https://doi.org/10.1016/j.jsams.2016.11.008.

68. Ruggeri, A.; Dancel, A.; Johnson, R.; Sargent, B. The Effect of Motor and Physical Activity Intervention on Motor Outcomes of Children with Autism Spectrum Disorder: A Systematic Review. *Autism* **2020**, *24*, 544–568. https://doi.org/10.1177/1362361319885215.
69. Pitetti, K.H.; Rendoff, A.D.; Grover, T.; Beets, M.W. The Efficacy of a 9-Month Treadmill Walking Program on the Exercise Capacity and Weight Reduction for Adolescents with Severe Autism. *J. Autism Dev. Disord.* **2007**, *37*, 997–1006. https://doi.org/10.1007/s10803-006-0238-3.
70. Moghadasi, M.; Arvin, H.; Rohbanfard, H.; Arsham, S.; Ostovar, A. Effect of Supervised Physical Exercise on Oxidative Stress in Children with Autism. *Cent. Eur. J. Sport Sci. Med.* **2024**, *46*, 45–51. https://doi.org/10.18276/cej.2024.2-04.
71. Suárez-Manzano, S.; Ruiz-Ariza, A.; de Loureiro, N.E.M.; Martínez-López, E.J. Effects of Physical Activity on Cognition, Behavior, and Motor Skills in Youth with Autism Spectrum Disorder: A Systematic Review of Intervention Studies. *Behav. Sci.* **2024**, *14*, 330. https://doi.org/10.3390/bs14040330.