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Developing Gross and Fine Motor Skills Using Sensory Integration in Children with Moderate Autism Spectrum Disorder

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Abstract

Sensory integration (SI)-based intervention programs aim to improve the motor performance of children with moderate autism spectrum disorder (MASD), which may contribute to the development of their gross and fine motor skills. This study aimed to explore the effectiveness of a SI-based training program in developing gross and fine motor skills in 70 children with MASD aged 6–9 years (M = 7.11, SD ± 1.19) and selected intentionally from a daycare center in Al-Ahsa in Saudi Arabia. The study used the quasi-experimental approach and followed the experimental design with two groups, which were randomly distributed and examined for equivalence. The study also used the Gross Motor Skills Scale (GMSS), the Fine Motor Skills Scale (FMSS), and the training program based on SI. The study found that the experimental group had significantly higher post-test scores in the GMSS and the FMSS than the control group, with these differences being statistically significant. However, no significant difference was observed between the post-test scores and the follow-up test scores within the experimental group, indicating stability in their performance over time. This indicates the effectiveness of the training program used in developing the targeted skills and the continuation of the training effect after the program's application period. The study suggests that children should use SI-based training programs to enhance their motor skills.

Keywords: Autism Spectrum Disorder, Fine Motor Skills, Gross Motor Skills, Sensory Integration.

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental illness marked by impaired communication, social interaction, and repetitive stereotyped behaviors (Liang et al., 2024; Restoy et al., 2024). The disorder is described as a spectrum that can range from mild to severe, with a variable impact on the child's quality of life (Longo et al., 2023). It often presents difficulties in sleeping and eating, emotional adjustment, thinking, and motor performance, and the deficits experienced by the child may persist throughout life (Liang et al., 2024; Wuang et al., 2020). Some ASD symptoms appear even as early as age 6 months. However, ASD is usually diagnosed at a late stage, leading to delayed access to intervention systems and worsening potential treatment outcomes (Minissi et al., 2023). Recent estimates have indicated that the prevalence of ASD has increased significantly from 1 in 68 children to 1 in 36 children, making it among the most prevalent developmental disorders. Children with ASD show delays in motor performance, which can significantly impact their daily activities and later developmental trajectories (Pan et al., 2024). Early detection of this disorder enables early intervention, which can improve developmental trajectories and enhance skills, especially motor skills (Perochon et al., 2023). The goal of early intervention for children with ASD is to promote participation in routines and activities; however, little is known about the role of motor skills in these children’s participation in daily activities (Holloway et al., 2021).

In a related context, research shows difficulties in processing information, which prevents children with ASD from mastering the required motor performance, affecting their development (Tomilova et al., 2022). Children with ASD also show weakness or delays in motor skills, including postural control, motor coordination, and gross and fine motor skills; 87% of children with ASD show motor impairment (Sung et al., 2024). Notably, relationships exist between motor skills and a wide range of areas at different stages of development for these children. Motor skills significantly influence a child's perception, language, social development, performance, social communication, perception, and imitation, influencing their overall well-being from birth (Brian et al., 2024; Fears et al., 2022). According to Gonzalez et al. (2024), differences in motor skills exist between children with ASD and their peers without this disorder. These differences are more evident in gross motor skills (GMS), such as running and jumping, and fine motor skills (FMS), such as hand-eye coordination and tracking.

Rodríguez-Guerrero et al. (2023) state that studies conducted in medium to high sociocultural contexts indicate that motor skills are related to other developmental areas or domains, such as mathematics and language, especially at an early age. Generally, it can be concluded that children with ASD have delays in motor skill development compared to typical children (Oliveira et al., 2023). Research shows many positive effects of physical exercise (Castaño et al., 2024), as motor skill interventions can help improve motor skills, which may increase the likelihood of these children participating in physical activity and the possibility of building their social skills (Colombo-Dougovito & Block, 2019). A study by Rodríguez-Guerrero et al. (2023) suggests that GMS may have a greater effect on the development and acquisition of certain skills than FMS.

GMS involves whole-body movement, core stabilizing muscles, eye-hand coordination, and daily functions such as standing, walking, running, jumping, sitting, and riding a bike or scooter. GMS is crucial for children’s daily functions, such as walking, running, climbing, and sports, as well as daily self-care skills, such as dressing, climbing, and climbing into and out of cars or beds (Kid Sense, 2024). GMS includes a range of daily movements, such as standing, walking, running, sitting upright without back support, chewing, jumping, twisting the trunk, bending, moving, turning the neck, raising the arms and hands, and waving the arms. They also include hand-eye and foot-eye coordination skills, such as throwing and catching a ball, kicking a ball, and performing movements such as cartwheeling, jumping, swimming, riding a bike or skateboard, and ice skating or skiing (Cleveland Clinic, 2023).

FMS is essential for many daily activities, such as handling toys or objects, dressing, and personal care. In recent years, research has increasingly focused on the FMS of children with ASD and how these skills relate to their cognitive abilities (Lin et al., 2024). FMS is an aspect of motor development that should be developed in early childhood. Fine motor development is vital in a child’s development because it represents their ability to demonstrate and master fine muscle movements with coordination, agility, and skills (Hanafiah et al., 2023).

FMS are fine movements performed by small muscles that require precise coordination between eyes and hands. They involve tasks such as picking up objects, inserting objects into holes, creating artwork, drawing, coloring, writing, and tearing paper. Children with ASD must learn new, easier skills at an early age to develop their FMS, as they lack the appropriate skills for their abilities. This early development helps them become more confident and bolder in their FMS development (Riyadi et al., 2023). FMS can be developed through various activities such as picking up small objects (such as beads and buttons); using the thumb and index finger; playing with dough; cutting, pressing, and decorating shells or pasta; loosening and tightening nuts; using building sets; and wrapping a rubber band around a pencil, in addition to using chopsticks (Laurie, 2022). Toys, which can be used for multiple purposes, can also be used as assistive technology in the treatment process to develop FMS that are indispensable for the child in daily tasks, which are stressful for children with ASD (Azevedo et al., 2023).

Since children with ASD struggle to organize and integrate sensory inputs, which lead to their inability to respond appropriately to these inputs, they have sensory disturbances that lead to inappropriate responses to environmental events, which hinders the appropriate performance of daily activities. An effective method to improve sensory processing in children with ASD is sensory integration (Behrouzmanesh et al., 2023). Sensory integration (SI) is a type of intervention that involves a therapeutic approach that enhances the brain's ability to process and integrate sensory information. It includes various senses like touch, balance, movement, and hearing, improving brain organization, adaptive responses, concentration, motor skills, and social engagement, ultimately improving quality of life (Raditha et al., 2023).

SI is an intervention involving face-to-face interaction with play and sensory-motor activities, aiming to reduce stress levels in children with ASD. It improves coordination, adaptive responses, and attention skills. SI involves organizing sensory information for motor performance, and a recent definition of SI disorder includes difficulty detecting, modifying, interpreting, and responding to severe sensory experiences that interfere with daily living activities (Camarata et al., 2020; Pergantis & Drigas, 2023). SI is based on the role of vestibular, tactile, and proprioceptive senses as a key component, which assists in the effective integration of the senses. Consequently, postural control, maintenance of muscle tone, and emotional stability are developed, which can contribute to improved motor planning and sensory processing, which are the foundation for improving skills required for activities of daily living and social engagement, such as peer play, daily activities, and learning (Oh et al., 2024). Up to 90% of children with ASD exhibit sensory characteristics that may negatively impact participation in daily routines and activities; therefore, functional intervention can be delivered based on SI principles, and data-driven decision-making is used to guide clinical reasoning. Assessment data are analyzed and used to develop hypotheses about underlying sensorimotor factors that influence activity and task engagement, intervention work, and outcome measurement (Schiano et al., 2024). Given the complexities of ASD and the importance of SI cues for maintaining balance in children with ASD, motor activity interventions appear to be among the most beneficial approaches to regulate and reduce balance deficits (Ben Hassen et al., 2023).

Although SI is among the most widely used interventions in the field of ASD, no consensus exists on its evidence base; a growing number of studies have investigated its effectiveness (Schoen et al., 2019). However, Schiano et al. (2024) noted that SI is an evidence-based, practical, functional intervention for children with ASD that is delivered in person and can be adapted to telehealth services to fill gaps in services for families struggling to access them. SI disorder symptoms vary in complexity and emerge differently in each child. Children with SI problems may have difficulty interacting with their surroundings. These challenges can also impact the child’s gross and fine motor development, balance, coordination, visual perception, and self-care abilities (Jurevičienė et al., 2023).

Children with ASD face a range of challenges in developing GMS and FMS, which impacts their ability to perform daily activities and social interaction. Talkar et al. (2025) found significant delays in FMS development in children with ASD and an association between dominant manual imitation skills and the severity of ASD symptoms. Taverna et al. (2021) confirmed that children with ASD have persistent difficulties in performing FMS. This limits motor development in children, especially the ability to move their fingers and toes (Abdullah et al., 2024). Many studies, including this one, have found SI effective in enhancing various skills in these children. However, based on the researchers’ knowledge, studies addressing the use of SI with children with ASD in the Saudi environment are scarce. In Egypt, Mustafa (2021) employed SI activities to improve some sensory functions (movement dimension) in kindergarten children with ASD. Moreover, Mohammed et al. (2020) employed SI activities to develop sensorimotor abilities related to balance, walking, running, jumping, crawling, and imitating various movements and positions of the body in children with ASD. A case study in Algeria by Fouires and Meherzi (2024) indicated the effectiveness of SI in developing motor skills in a single adolescent with ASD. A study by Oh et al. (2024) conducted in Korea showed the effectiveness of SI in developing FMS and GMS, and Papadopoulos and Vasileiadis (2024) showed a significant improvement in visual perception and motor integration after intervention in participants with special educational needs. Research on SI treatments for GMS and FMS development in children with ASD has flaws, including insufficient sample size, cultural and contextual variations, inconsistency in results, credibility issues, and challenges in assessing sustainability beyond treatment completion. Furthermore, no field studies evaluate the effectiveness of SI training programs in enhancing GMS and FMS in this context within Saudi Arabia. Based on the work of authors in a day center, an urgent need emerged to develop educational and intervention strategies targeting the improvement of FMS in children with ASD, and they found SI a promising method in this field, as it aims to enhance coordination between the different senses, which directly contributes to improving GMS and FMS. Accordingly, this study evaluates the effectiveness of a training program based on SI in developing GMS and FMS. The study highlights this gap where it can contribute to developing effective intervention strategies, enhancing these children's skills, and helping them achieve greater independence, in addition to providing valuable insights for specialists on how to manage these children. Since the study aims to examine the effectiveness of a training program based on SI in developing GMS and FMS in a sample of children with ASD, it is considered an opportunity to provide practical and innovative solutions to address the challenges faced by children with ASD in Al-Ahsa, which contributes to improving their quality of life and enhancing their social integration. The study questions are as follows:

- What is the post-test difference in mean GMSS scores between the experimental and control groups?
- What is the post-test difference in mean FMSS scores between the experimental and control groups?
- What is the difference between the experimental group's mean GMSS scores in the pre-test and post-test?
- What is the difference between the experimental group's mean FMSS scores in the pre-test and post-test?
- What is the difference between the experimental group's mean GMSS scores in the follow-up and post-test?
- What is the difference between the experimental group's mean FMSS scores in the follow-up and post-test?

2. Methodology

Study Design and Setting

The study used the quasi-experimental method, considering that the research is an experiment seeking to examine the effectiveness of SI, which is considered among the evidence-based interventions (independent variable) in developing FMS (dependent variable). Thus, the method used is appropriate for the research. Accordingly, a two-group design was used, and then the experiment was applied to an experimental group of children with moderate autism spectrum disorder (MASD), while the control group was not exposed to any other intervention.

Participants

Seventy children were selected intentionally from a care center for children with MASD in Al-Ahsa in the Eastern Province of Saudi Arabia. Their chronological ages ranged from 6–9 years (M= 7.11, SD ± 1.19). The decision to include only male participants was made to control for potential variables related to gender differences in motor skill development, ensuring a more homogenous sample for this study. This choice also reflects the cultural and social considerations in Saudi Arabia, where educational and social norms often dictate gender-segregated environments, particularly in specific developmental contexts. They were divided and distributed randomly into two equal groups, one experimental and the other control. Equivalence was achieved between the two groups in terms of age, intelligence, ASD, GMS, and FMS. The probability value was below 0.05, indicating the equivalence of the two groups. The participants were selected based on the following conditions:

- Their chronological ages ranged from 6–9 years.
- According to the Stanford-Binet Scale (fifth edition), their intelligence score was 38–48.
- They were diagnosed with MASD.
- They showed weaknesses in GMS and FMS such that their scores were below average according to the scale used in this study.

They had no accompanying disabilities.

They took no medications affecting developmental or behavioral aspects throughout the implementation of the training program.

Study Tools

Gross Motor Skills Scale (GMSS)

This scale was prepared by Hussanin (2019) and involved 80 children. A three-point Likert scale was used to answer these statements, where three responses were placed in front of each statement: always = 2, sometimes = 1, and rarely = 0. Accordingly, the maximum score was 160, the mean score 80, and the minimum score zero, where the maximum score indicated a high level of GMS, and the minimum score indicated a deficiency in the GMS performance.

The developer of the scale verified its original version for psychometric efficiency, where validity was calculated by calculating the internal consistency of the scale on a sample of 54 children, where the correlation coefficients between the scale items and the total score of the scale were .353–.864. The reliability was also calculated using Cronbach's alpha and the split-half method using the Spearman-Brown and Guttman equations. Cronbach's alpha was .934, and the split-half reliability coefficient was .889 using the Spearman-Brown equation and .858 using the Guttman equation. This indicates that the scale has high validity and reliability.

The authors in the current study also verified the validity and reliability of this scale in the Saudi environment, where its internal consistency was calculated on a sample of 68 children, and the correlation coefficients between the scale items and the total score of the scale were .536– .905. The reliability was also calculated using the retest method, where the scale was reapplied to the same sample 2 weeks after the first application. After applying the responses and estimating the scores, r, the reliability coefficient between the scores in the two applications, was equal to .898 for the total score, which was significant at .01.

Fine Motor Skills Scale (FMSS)

This scale was prepared by Hussanin (2019) and involved 50 children. A three-point Likert scale was used to answer these statements, where three responses were placed in front of each statement: always = 2, sometimes = 1, and rarely = 0. Accordingly, the maximum score was 100, the average score was 50, and the minimum score was zero, where the maximum score indicates a high level of FMS, and the minimum score indicates a deficiency in the performance of these skills.

The scale's original version was verified by its developer for psychometric efficiency, where validity was calculated by calculating the internal consistency of the scale on a sample of 54 children with ASD and the correlation coefficients between the scale items and the total score of the scale were .345– .836. The reliability was also calculated using Cronbach's alpha and the split-half method using the Spearman-Brown and Guttman equations, where Cronbach's alpha was .877. The split-half reliability coefficient was .838 using the Spearman-Brown equation and .757 using the Guttman equation. This indicates that the scale has high validity and reliability.

The authors in the current study also verified the validity and reliability of this scale in the Saudi environment, where its internal consistency was calculated on a sample of 68 children with MASD, and the correlation coefficients between the scale items and the total score of the scale were .417– .891. The reliability was also calculated using the retest method, where the scale was reapplied to the same sample 2 weeks after the first application. After applying the responses and estimating the scores, r, the reliability coefficient between the scores in the two applications, was equal to .880 for the total score, which was significant at .01.

Training Program

The training program was prepared based on SI to develop GMS and FMS in children with MASD (experimental group) by performing various activities and tasks based on SI tools, in addition to using techniques facilitating the training process and ensuring the continuity of its effect after the completion of the program.

The training program was presented to a specialized group of faculty members and experts in the field of MASD to evaluate its validity. In its final form, the program included 48 sessions applied at a rate of three sessions per week over 4 months, with each session lasting 45 minutes. It was applied to the experimental group throughout the period specified for the program application, noting that members of the control group were not trained on this program or any other intervention. The training program was divided into three main stages, each of which included a specific number of sessions that aimed to achieve a set of specific goals, as shown in Table 1:

Table 1. Summary of Training Program Stages for GMS and FMS Development in Children with ASD

Stage	Description
Introductory stage	This included two sessions for the authors and participants to become acquainted and to introduce the participants to the program, activities, and tasks that they would be trained on, in addition to conducting a pre-assessment of GMS and FMS according to the scale used in the research.
Training stage	This included 42 sessions to train the participants in the experiment on the activities and tasks targeted in the training program, including the following: For GMS: This included sessions 3–21, which aimed to achieve the following objectives: rolling a ball; jumping in place with both feet; sitting in a squatting position and then returning to standing; climbing the stairs by alternating feet; descending the stairs by alternating feet; kicking a large ball with the foot; walking on a balance beam forward, backward, and sideways; jumping backward several times; somersaulting forward; running several steps with the arms moving in a coordinated and reciprocal movement; standing on one foot; bouncing a large ball on the ground and catching it; using a skipping rope without assistance; riding a three-wheeled bicycle while changing direction; running through obstacles while avoiding objects; jumping forward two feet with the feet together; and jumping between squares drawn on the ground. These activities were carried out in an organized manner throughout each session led by the authors. Each activity began with a presentation, followed by group practice. Participants were invited to complete the activities at their own pace. Regular assessments were carried out to monitor development and make required adjustments to the activities to fit individual requirements. For FMS: Sessions 22–42 included the following objectives: assembling puzzles; building cubes; coloring, from coloring inside a frame to coloring simple shapes so that each part was colored in a different color; joining beads, from joining beads in one color to joining colored beads in specific patterns; cutting paper from the easiest to the most difficult; drawing lines (vertical, horizontal, broken, curved) to connect the same geometric shapes; making shapes from clay starting from geometric shapes such as a circle, square, or triangle, to shapes such as a snake, rose, glasses, or basket; transferring small objects from one plate to another (such as large beads, small beads, pasta grains, or rice grains); and gluing sand to simple drawings with glue. The necessary tools were then provided to perform these activities, including puzzles, cubes, drawing books, scissors, beads, colored pencils, sand, water, and clay. The techniques of the training program were represented in positive reinforcement, verbal and manual indoctrination, modeling, role-playing, and feedback. The steps of the program sessions were represented in the following aspects: Before training: The authors removed any distractions from the SI room that would attract the children's attention and ensured the children did not need food, a bathroom, or sleep. They also ensured the tools for the targeted session were ready inside the room. During training: At the beginning of the training, the children's attention was attracted through visual stimuli, such as following a spotlight moving in a dark row, then following a spotlight in a lit row, as well as training the children to hold soap bubbles with their hands, pick up a ball with both hands, and transfer plastic balls from one plate to another with a spoon, and other exercises. They then started with simple GMS and FMS that children can master quickly to encourage and motivate them using manual guidance at the beginning of training. The training gradually moved to directing children with a sign and reinforcing them immediately after performing the correct behavior. It progressively moved to intermittent and varied reinforcement; the training concluded with a successful skill for the children, and they were praised. After training: This training included a thorough workshop that covered the objectives and tactics employed in the original sessions, with a focus on positive reinforcement, verbal and manual instruction, modeling, role-playing, and delivering constructive feedback. The training also featured practical demonstrations and role-playing situations to ensure that the activities were carried out effectively by the authors. Furthermore, training tools such as manuals and instructional videos were provided to aid in continual learning and application.

Evaluation stage	This included four sessions to evaluate the participants' performances in the activities and tasks they were trained on in the training stage based on the scale used in the research.

Data Collection

Demographic information for the two research groups, such as age, gender, IQ, and ASD, was collected from updated records of children at the center where the research was implemented, according to the conditions for selecting research participants. The data collection tools were used during the pre-test (May 5, 2024), the post-test (August 28, 2024), and the follow-up test (September 30, 2024). The authors at the center completed these assessments to ensure that the data collection procedure was consistent and reliable. Between May and September 2024, data on GMS and FMS were also collected following test standardization.

Data Analysis

The research objectives were achieved using a quasi-experimental approach and following a design with two groups, experimental and control, to answer the three research questions, using IBM SPSS version 26, after collecting the data in Excel and then transferring them to the statistical program and coding them. To determine the normality of the data distribution, the authors used normality tests such as the Shapiro-Wilk test and the Kolmogorov-Smirnov test. The results showed that the p-values for these tests were greater than .05, indicating that the data did not deviate significantly from the normal distribution. As a result, the authors concluded that the data had a normal distribution, which supported the use of parametric statistics. A t-test was selected for independent samples to measure the difference between the average scores of the experimental and control groups, and a t-test was selected for paired samples to measure the difference between the average scores of the experimental group in the pre- and post-tests and the post- and follow-up tests.

3. Results

Question 1

What is the post-test difference in mean GMSS scores between the experimental and control groups? An independent sample t-test was used to answer this question.

Table 2 indicates a statistically significant difference between the mean GMSS scores of the experimental group (EG; M = 149.4) and those of the control group (CG; M = 66.7). Regarding the mean scores, this difference favors the larger mean, that of the EG (t = 75.5, p < .001).

Table 2. T-Test Results Comparing the Mean GMSS Scores of the EG and CG in the Post-Test

Scale	EG (n = 35)		(CG = 35)		t	df	p
	M	SD	M	SD			
GMSS	149.4	3.81	66.7	5.24	75.5	68	<.001

Question 2

What is the post-test difference in mean FMSS scores between the EG and CG? An independent sample t-test was used to answer this question.

Table 3 indicates a statistically significant difference between the mean FMSS scores of the EG (M = 88.1) and those of the CG (M = 53.1). Regarding the mean scores, this difference favors the larger mean, that of the EG (t = 41.8, p < .001).

Table 3. T-Test Results Comparing the Mean FMSS Scores of the EG and CG Groups in the Post-Test

Scale	EG (n = 35)		(CG = 35)		t	df	p
	M	SD	M	SD			
FMSS	88.1	3.87	35.1	6.43	41.8	68	<.001

Question 3

What is the difference between the EG's mean GMSS scores in the pre-test and post-test? A paired samples t-test was used to answer this question.

Table 4 shows a difference between the mean GMSS scores of the EG in the post-test (M = 149.1) and the pre-test (M = 65.9). Regarding the mean scores, this difference favors the larger mean, which is the post-test mean (t = 76.5, p < .001), confirming that this difference is statistically significant between the mean scores of the EG in the pre-test and post-test in favor of the post-test.

Table 4. T-Test Results Comparing the Mean GMSS Scores of the EG in the Pre-Test and Post-Tests

Scale	Tests	M	Mean Difference	SE Difference	t	df	p
GMSS	Post	149.4	83.5	6.5	76.5	34	<.001
	Pre	65.9					

Question 4

What is the difference between the EG's mean FMSS scores in the pre-test and post-test? A paired samples t-test was used to answer this question.

Table 5 shows a difference between the mean FMSS scores of the EG in the post-test (M = 88.1) and the pre-test (M = 33.5). Regarding the mean scores, this difference favors the larger mean, the post-test mean (t = 49.3, p < .001), confirming that this difference is statistically significant between the mean scores of the EG in the pre-test and post-test in favor of the post-test.

Table 5. T-Test Results Comparing the Mean FMSS Scores of the EG in the Pre-Test and Post-Tests

Scale	Tests	M	Mean Difference	SE Difference	t	df	p
FMSS	Post	88.1	54.5	6.6	49.3	34	<.001
	Pre	33.5					

Question 5

What is the difference between the EG's mean GMSS scores in the follow-up and post-test? A paired samples t-test was used to answer this question.

Table 6 indicates no difference between the mean FMSS scores of the EG in the post-test (M = 149.4) and follow-up (M = 149.1; t = 0.918, p = 0.365), indicating no statistically significant difference between the mean scores of the EG in the post-test and follow-up.

Table 6. T-Test Results Comparing the Mean GMSS Scores of the EG In the Post-Test and Follow-Up

Scale	Tests	M	Mean Difference	SE Difference	t	df	p
GMSS	Post	149.4	.314	2.03	.918	34	.365
	Follow-up	149.1					

Question 6

What is the difference between the EG's mean FMSS scores in the follow-up and post-test? A paired samples t-test was used to answer this question.

Table 7 indicates no difference between the mean FMSS scores of the EG in the post-test (M = 88.1) and follow-up (M = 87.7; t = 1.93, p = .062), indicating no statistically significant difference between the mean scores of the EG in the post-test and follow-up.

Table 7. T-Test Results Comparing the Mean FMSS Scores of the EG in the Post-Test and Follow-up

Scale	Tests	M	Mean Difference	SE Difference	t	df	p
FMSS	Post	88.1	.371	1.14	1.93	34	.062
	Follow-up	87.7					

4. Discussion

The study results indicate the effectiveness of SI in developing GMS and FMS among the participants in the EG with MASD. A difference was found between the EG and CG in the post-test. Additionally, the results showed a difference between the pre- and post-tests within the EG, indicating that the children in this group achieved a significant improvement in GMS and FMS after applying the program, suggesting that the training program had a clear positive, also significant, impact on the development of the targeted skills. This result is consistent with other research, like that of Colombo-

Dougovito and Block (2019), which found that motor skill therapies had a positive influence on children with ASD. However, the current study goes beyond this notion by revealing specific improvements in both GMS and FMS as a result of the SI program. Unlike Mustafa's (2021) focus on sensory functioning, this work emphasizes the development of both GMS and FMS, signifying a broader use of SI treatments. Furthermore, Mohammed et al. (2020) looked into how SI activities can help children with sensory processing disorders. However, the results of this study show that these activities not only help with symptoms but also make a big difference in skill development. Furthermore, Oliveira et al. (2023) emphasized the relevance of specific motor abilities in participation outcomes. This supports the results of this research, which show significant gains in motor proficiency among children in the EG. In contrast to Brian et al. (2024), who saw gains in social and motor abilities, the current study focuses on the structured aspect of the training program and its direct association with skill growth. While Castaño et al. (2024) found advantages from systematic physical activity, this study highlights significant variations in GMS between the EG and CG. Fouires and Meherzi (2024) recognized the importance of SI for adolescents' motor skills, Oh et al. (2024), on the other hand, established its effectiveness in improving a variety of skills, including FMS. The results of this study confirm these conclusions, underlining the necessity for tailored treatments for children. Finally, while Papadopoulos and Vasileiadis (2024) reported improvements in visual perception and motor integration, this study focuses on the overall importance of SI on motor skill development, contributing to a better understanding of how to optimize these interventions for children with ASD.

To enhance the explanation regarding the effectiveness of SI in developing GMS and FMS among children in the EG, the authors explain that several factors contributed to the positive results. First, repetition and practice were crucial, as frequent engagement in activities allowed children to reinforce their motor skills and develop motor memory. Second, the variety of activities, such as cutting, coloring, and assembling, likely improved engagement and participation, leading to better learning outcomes. Lastly, ongoing support from authors may have motivated children to continue learning, resulting in improved performance.

However, the results showed no difference within the EG in the post-test and follow-up tests. This may indicate that the significant improvement achieved during the program period continued for a month after the end of the training. This result is consistent with the study by Al-Jarhi (2018), which showed a continued improvement achieved by children in the EG in each of the sensory, behavioral problems related to tactile processing, the sense of the body position in space, and the deep sense of movement, and the study by Mustafa (2021), which verified the continued effect of training with SI activities in improving movement after the training program had been applied. This sustained performance can be attributed to several factors, including regular practice of abilities, which reinforces motor memory, and the authors' supportive circumstances, which allowed for the application of skills in a variety of settings. Positive reinforcement and social contacts are likely to have boosted the children's motivation and confidence, allowing them to retain skills and adapt to diverse situations.

In general, while several studies have investigated SI treatments for children with MASD, this study focuses on a specific demographic: children with MASD in Saudi Arabia. In addition, previous studies, such as those conducted in Western contexts, sometimes involve larger age groups or distinct cultural settings, which may fail to account for the sociocultural influences influencing motor skill development in Saudi children. Furthermore, many existing studies do not provide a full examination of long-term effects, whereas the current study includes follow-up tests to determine the long-term viability of GMS and FMS improvements post-intervention. Furthermore, this study uses a carefully structured SI-based training program that is designed precisely to the needs of the participants, resulting in a more nuanced approach to improving GMS and FMS. This current study methodology distinguishes work from other research methodologies, which may use general SI activities without taking into account the participants' individual developmental situations. This study adds to the existing body of knowledge on SI treatments while simultaneously filling a key vacuum by offering culturally appropriate insights and a targeted evaluation of GMS and FMS development in Saudi Arabian children with MASD. This uniqueness emphasizes the importance of these findings and their potential impact on future treatments in comparable settings.

5. Conclusion

This study is one of the few that applied the SI program to improve GMS and FMS in children with ASD in Saudi Arabia, which contributes to bridging a knowledge gap in this field. The study showed a sustainable positive impact of the program on the age group (6-9 years), as the improvements continued for a month after the program ended. The reliability of the measurement tools was also examined to suit the local context, in addition to providing detailed activities that can be used as a reference for developing similar programs. The study highlighted the importance of SI as a multi-benefit tool that is not limited to improving motor skills only but also includes enhancing social interaction and independence. These results open new horizons for developing sustainable intervention programs that support the quality of life for Saudi children with ASD.

6. Recommendations

Based on the research results, further research should be conducted that includes larger samples of children with MASD to evaluate the effectiveness of the program and generalize its results. It is also advised that the sample be expanded to include children with mild and severe ASD, as well as children from various geographical regions within Saudi Arabia, to ensure that the results are more representative and applicable. The follow-up period of the program should be extended by up to 2 months to ensure improvement in the acquired skills and prevent their decline among the participants in the training program. Moreover, longitudinal studies should be conducted to measure GMS and FMS after the end of the program to understand the extent of the continuity of improvement, and adding new activities that suit the diverse needs of these children could further enhance the results. Additionally, future research should also include gender-specific comparison analyses to investigate potential differences in the effectiveness of sensory integration programs for boys and girls with ASD, since this could provide significant insights into personalizing interventions based on gender needs. Finally, future studies should investigate the impact of the program on other aspects such as visual performance, attention, joint attention, reducing hyperactivity, sensory functions, and stereotypical behavior, which may contribute to increasing the level of communication and social interaction among these children to ensure better integration within society.

7. Limitations

Despite the positive results shown by the study, which indicate the effectiveness of the training program based on SI in developing GMS and FMS among the participants with MASD (members of the EG), the authors faced several limitations, including the following: The sample size was limited because the study was applied to a sample of children with ASD, who were selected intentionally in only one center in Al-Ahsa, which limits the generalization of the results. The focus was also on children with MASD (trainable only), limiting the possibility of generalizing the results to mild and severe degrees of ASD. Additionally, the tool used to measure GMS and FMS may need to be developed and validated for psychometric efficiency on a larger sample. Moreover, the period of application of the program may be insufficient to improve all FMS. The program should ideally last 6 months to improve the largest possible number of GMS and FMS, as well as extend the follow-up period to verify the continuation of the training effect and maintenance of improvements in GMS and FMS among the study participants.

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