ORIGINAL ARTICLE

Impact of Sensory Integration Therapy on Gross and Fine Motor Skills in Preschool Children with Autism Spectrum Disorder: A Pre-Post Interventional Study

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ABSTRACT

Objective: To evaluate the effectiveness of sensory integration therapy (SIT) on gross and fine motor skills in preschool children diagnosed with autism spectrum disorder (ASD).

Study Design: Quasi-experimental (Pre-post interventional) study.

Place and Duration of Study: Department of Developmental and Behavioral Pediatrics, The Children's Hospital and Institute of Child Health, Multan, from January to December 2025.

Methodology: Forty-four children with ASD, aged 36–60 months, were enrolled. Gross and fine motor skills were assessed at the time of enrollment and after six months of therapy, using the Peabody Developmental Motor Scales, Second Edition (PDMS-2). The children received individualized SIT, three times per week. Data were analyzed using the paired t-test, with p value less than 0.05 considered statistically significant.

Results: The study included 44 children (26 males; mean age 49.21 ± 6.25 months). Following 72 sessions of sensory integration therapy, significant improvements were observed in all PDMS-2 domains. Gross Motor Quotient improved by 19 points, Fine Motor Quotient by 15 points, and Total Motor Quotient by 17 points. The largest gains were observed in visual-motor integration (+25 raw score points) and grasping skills (+31 months' age-equivalent gain). All improvements reached statistical significance ($p<0.001$).

Conclusion: Sensory integration therapy is associated with statistically significant improvements in gross and fine motor skills among preschool children with ASD. These findings support the inclusion of SIT within multidisciplinary rehabilitation protocols. Given the quasi-experimental nature of this study and the absence of a control group, further randomized controlled trials are required to validate these clinical facts.

Keywords: *Autism spectrum disorder, Motor skills, PDMS-2, Sensory Integration Therapy*.

INTRODUCTION

Autism Spectrum Disorder (ASD), is a neurodevelopmental disorder that has been receiving increased consideration by clinicians and researchers throughout the world. ASD is characterized by long-standing social communication and social interaction challenges along with restrictive/repetitive patterns of behavior, interest and activity.[1]The impact of ASD can be quite variable; ranging from moderate to severe and significantly impacting a child's daily functioning. Awareness about ASD is growing in many clinical settings across South Asia including Pakistan.[2] However, there remains limited use of evidenced based treatments as well as limited study of those treatments within our local populations.[3]

A very important area of focus regarding ASD is sensory processing dysfunction. Research indicates that approximately 42-88% of children diagnosed with ASD experience extreme difficulty processing and integrating various forms of sensory stimulation from their environment.[4] A number of children with ASD also experience low muscle tone or hypotonia. Low muscle tone is considered an early indicator of more severe autism related symptomology and lower overall quality of life in young children.[5] In addition to low muscle tone, challenges are frequently seen in other areas such as somatosensory processing, proprioception, balance, mood regulation, and concentration.[6] These challenges individually and collectively create barriers to normal development.

The unique mannerisms and behaviors associated with children with ASD illustrate that the central nervous system struggles to combine various forms of sensory input into a unified whole. Self-stimulating behaviors commonly exhibited by children with ASD are examples of repeated movement(s) that appear non-purposeful and are most likely performed either to receive additional sensory input or to reduce feelings of overwhelm.[7] As a result, these behaviors can hinder children with ASD from participating in learning and therapeutic interventions. Furthermore, research studies have demonstrated that children with ASD also demonstrate challenges balancing while relying heavily upon somatosensory processing. This further supports the idea of a larger issue pertaining to integrating sensory input.

The Sensory Integration Therapy (SIT) was initially designed by an occupational therapist Dr. A. Jean Ayres. The technique is grounded on the assumption that the structured therapist-directed sensory input involving vestibular, proprioceptive, and tactile sensations may increase sensory organization abilities and responses.[8] Such instruments as therapy swings, balance boards, weighted blankets, textured stimuli, and gym balls are used in order to provoke these sensations in a fun manner. Numerous clinical trials have proven that structured sensory integration techniques positively affect motor coordination, adaptive behavior, and participation in everyday activities.[9]

Although sensory integration therapy (SIT) is widely applied to children with ASD, its efficacy is still not supported by sufficient evidence. While several research findings have shown that SIT increases motor skills, adaptive behavior, and participation in daily activities, methodological weaknesses including small sample size, heterogeneous intervention, lack of control group, different outcome measures still limit the reliability of the evidence. In addition, only a few studies are conducted in high-income countries.

This is a gap in knowledge that applies especially to countries like Pakistan, where there is a lack of availability of rehabilitation programs and thus evidence generated locally would be useful for guiding the treatment approach. Motor difficulties that occur in children with ASD range further than just developmentally related issues and can have major effects on self-care, school preparedness, social engagement, and quality of life in general. While there have been more cases recognized, there is still a lack of evidence with respect to the benefits of SIT on motor function among South Asian people. There have also been very few studies that have used PDMS-2 to assess changes in motor function.

Keeping these deficiencies in mind, the study aimed to evaluate the efficacy of six months'

sensory integration therapy on gross motor, fine motor, and motor skills of preschool children with ASD using PDMS-2 as an objective outcome measure to generate local evidence that can add to the current literature on sensory interventions in children with ASD and help direct rehabilitation strategies in a resource limited clinical context. The majority of studies supporting SIT have been found to be heterogeneous and of varied quality. Previous systematic reviews highlighted problems with the quality of research including small sample sizes, no appropriate controls, and inconsistent measures.[10] Even though sensory integration therapy is commonly being implemented among children with ASD by occupational therapists worldwide, there is limited evidence to support the efficacy of SIT on gross and fine motor skills among children with ASD in countries with limited number of trained therapists and validated assessment tools.

Autism also has practical implications in the clinical setting. Children with ASD display motor impairments that have consequences on their daily activities, attending school, and socializing with family members and the community. Deficits in kinesthetic processing, poor visuospatial integration and coordination, and the need for sensory processing that recruits multiple sensory modalities have been demonstrated in these patients.[11] However, it is unknown if sensory integration therapy in a structured format can provide long-term benefits to motor function in children with ASD seen in a clinical setting like ours. The present study aimed at exploring whether there could be an improvement in gross, fine and motor skills in mildly to moderately affected children diagnosed with autism using a six-month treatment program that included sensory integration therapy. The study was conducted at the Children's Hospital and Institute of Child Health, Multan, which happens to be one of the largest public health facilities specializing in pediatric health care in the southern part of Punjab province.

MATERIAL AND METHODS

The study employed a pre-test post-test quasi-experimental design to investigate motor skill development, carried out over a six-month duration from July 1, 2022, to December 31, 2022, at the Department of Developmental and Behavioral Pediatrics, Children's Hospital and the Institute of Child Health, Multan, Pakistan. Our cohort comprised 44 children diagnosed with Autism Spectrum Disorder 26 boys and 18 girls with a mean age of 49.21 ± 6.25 months. Participants were enrolled consecutively from the outpatient clinic. Eligible children had a confirmed diagnosis of mild-to-moderate ASD, with a Childhood Autism Rating Scale score between 25 and 35.[17,18] Their IQ ranged from 69 to 83 on the Stanford-Binet Intelligence Scale.[19] All participants could follow simple verbal commands. Children with visual or hearing deficits that were not corrected were not included. Those with epilepsy, cerebral palsy, or other neurological and musculoskeletal disorders affecting motor performance were also excluded.

The study approval was obtained from the Institutional Ethics Committee (No. 1048, dated 01-01-2025). Written informed consent was obtained from the parents of all participants. All assessments were carried out in a quiet environment with minimal distractions to ensure reliable results. The chronological age of each child was calculated at the time of assessment to allow accurate comparison with age-based normative values. Assessments were performed at baseline and repeated after completion of the 6-month of therapy period.

Motor performance was evaluated using the five subtests of the Peabody Developmental Motor Scales–Second Edition (PDMS-2). Gross motor abilities were assessed through the stationary, locomotion, and object manipulation subtests. The stationary subtest evaluated balance and postural control, while the locomotion subtest assessed movement skills such as walking, running, and jumping. The object manipulation subtest measured abilities related to throwing, catching, and ball handling. Fine motor skills were assessed using the grasping and visual-motor integration subtests. The grasping subtest evaluated hand and finger control, whereas the visual-motor integration subtest assessed eye–hand coordination during structured tasks. Each item was scored according to the PDMS-2 scoring criteria. Children were given an opportunity to understand and practice the task before formal scoring. Raw scores from the individual subtests

were converted into standard scores and combined to calculate the Gross Motor Quotient (GMQ), Fine Motor Quotient (FMQ), and Total Motor Quotient (TMQ). Age-equivalent scores were also obtained to assist in clinical interpretation.

The intervention consisted of an individualized sensory integration therapy (SIT) program delivered by a qualified occupational therapist. Therapy sessions were conducted three times per week, with a total of 72 sessions. All sessions took place in a dedicated sensory therapy room. The treatment plan was individualized according to each child's sensory needs and response to therapy. Activities were designed to encourage active participation and maintain the child's interest throughout the sessions. Tactile stimulation was provided through activities involving different textures, including finger painting and other sensory play tasks. These activities also helped improve fine motor skills such as pencil grasp and manipulation of buttons and fasteners. Vestibular stimulation was provided through swinging, spinning, and balance activities aimed at improving movement awareness and postural control. In selected activities, children wore blindfolds to reduce visual input and enhance vestibular processing. Proprioceptive input was addressed through "heavy work" activities such as pushing, pulling, lifting, and deep-pressure tasks. These activities were intended to improve body awareness, motor planning, and overall motor coordination.

Data analysis was performed using descriptive and inferential statistics. Continuous data were expressed as mean ± standard deviation (SD).The paired-samples t-test was used to compare baseline and post-treatment scores of the PDMS-2 subtests and motor quotients. A p-value of ≤ 0.05 was taken as statistically significant.

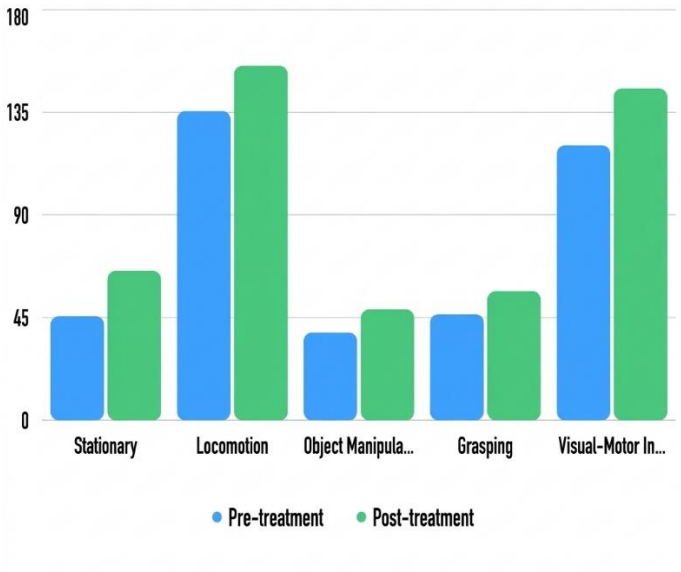
RESULTS

The study population included 44 children who were with the diagnosis of Autism Spectrum Disorder (ASD), 26 males (59.1%) and 18 females (40.9%) with a mean age of 49.21 ± 6.25 months (range 36-60 months). All of the participants completed the six months, 72 session of sensory integration therapy (SIT) intervention. Longitudinal comparisons revealed statistically significant improved performance in all gross and fine motor domains measured by the PDMS-2. The intervention yielded similar gains in raw motor scores, reflecting increased functional capacity across all subtests. As our analysis showed, the largest raw score increase was in the visual-motor integration domain (+25 points), and then improvements in the stationary and a locomotive domains (+20 points each).

Table 1. Mean Raw Scores of PDMS-2 Subtests Pre- and Post-Treatment Comparison (N=44)

PDMS-2 Subtest	Pre-treatment	Post-treatment	Change
Stationary	45	65	+20
Locomotion	135	155	+20
Object Manipulation	38	48	+10
Grasping	46	56	+10
Visual-Motor Integration	120	145	+25

Figure 1. Pre- and Post-Treatment Mean Raw Scores of PDMS-2 Subtests



These raw gains were accompanied by significant improvement in standardised scores, which provide a more reliable indicator of developmental progress relative to age-matched peers ($p < 0.05$). Standard scores for stationary and object manipulation doubled (5 to 10 and 6 to 10, respectively) and fine motor domains improved similarly.

Table 2. Comparison of Pre- and Post-Treatment Mean Standard Scores of PDMS-2 Subtests (N=44)

PDMS-2 Subtest	Pre-treatment	Post-treatment	Change
Stationary	5	10	+5
Locomotion	5	9	+4
Object Manipulation	6	10	+4
Grasping	4	8	+4
Visual-Motor Integration	8	11	+3

The intervention had an effect on how the participants developed over time. This was clear in their age- scores. Before the intervention many participants were behind their actual age in motor tasks. The program really helped them catch up. We saw improvements in their developmental age. Grasping skills improved the most with an increase of 31 months. Object manipulation skills improved by 26 months. Locomotion skills improved by 25 months. The intervention helped participants get better at motor tasks. It also helped them get closer to their age. Participants made progress in all areas. The program was successful, in helping them develop skills. The participant's developmental trajectories showed growth. They were able to do things they could not do before. Their motor skills improved a lot. The intervention made a difference in their lives. It helped them develop skills and get better at things.

Table 3. Comparison of Pre-Treatment and Post-Treatment Mean Age (Months) Equivalent Scores (N=44)

PDMS-2 Subtest	Pre-treatment	Post-treatment	Change
Stationary	38	58	+20
Locomotion	34	59	+25
Object Manipulation	32	58	+26
Grasping	27	58	+31
Visual-Motor Integration	39	54	+15

The improvements we made had an impact on the motor skills of the people in the study. The Gross Motor Quotient or GMQ went up from 80 to 99. The Fine Motor Quotient or FMQ also got better going from 82 to 97. When we look at the Total Motor Quotient or TMQ which's the best way to measure overall motor skills we see it went up from 81, to 98 and this change is significant.

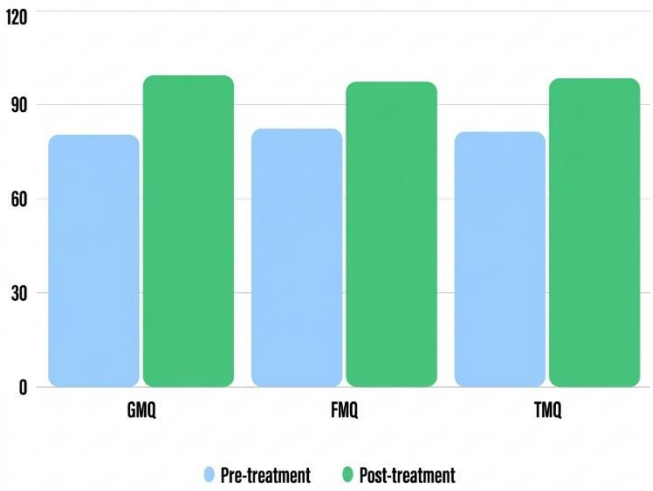
Table 3. Comparison of Pre-Treatment and Post-Treatment Mean Age (Months) Equivalent Scores (N=44)

Motor Quotient	Pre-treatment	Post-treatment	Change
Gross Motor Quotient (GMQ)	80	99	+19
Fine Motor Quotient (FMQ)	82	97	+15
Total Motor Quotient (TMQ)	81	98	+17

The way the kids with Autism Spectrum Disorder were doing changed a lot. At the start we saw that most of the kids had problems with movement. We looked at the kids at the beginning. We found out that a lot of them were not very good at

moving around. By the end of the study all 44 kids were doing much better. All of the kids with Autism Spectrum Disorder were doing average or better. This shows that the special sensory integration approach really helps kids, with Autism Spectrum Disorder get better at moving. The Autism Spectrum Disorder kids got a lot better at moving because of this approach.

Figure 2. Comparison of Gross Motor, Fine Motor, and Total Motor Quotients Before and After Sensory Integration Therapy



DISCUSSION

Among kids with Autism Spectrum Disorder, we checked if sensory integration therapy helps movement abilities. Six months later, gains showed up across all measures tracked by the Peabody test. Right hand totals rose. So did left hand ones. Both separate tasks and combined evaluations climbed too. Raw sums went up. Z-scores shifted higher. Even adjusted figures based on typical growth patterns reflected change. Percentile rankings moved ahead when compared to standard benchmarks. This shift suggests actual progress in small and large muscle coordination. Movement control got better through this approach.

Lately, research has made it clear - trouble with movement now counts as a key part of autism. Wobbliness, poor coordination, shaky balance, and stiff motions often block kids from playing, dressing themselves, or joining others. Right at the start, most children tested showed motor skills well under normal levels. Once they went through special exercises targeting inner-ear and body-awareness senses, things shifted. Their large-movement abilities got notably better - standing still without tipping, shifting positions smoothly, handling toys more easily. Progress here matters deeply; moving freely opens doors to staying active and connecting socially.

Equally compelling was the observed refinement in fine motor skills, specifically grasping mechanics and visual-motor integration. Mastery of fine motor tasks necessitates the seamless coupling of sensory feedback with exact motor execution. Activities ranging from tool utilization to self-care routines are highly dependent on the coordinated processing of visual, tactile, and proprioceptive inputs.[14] The notable progress in visual-motor integration within our cohort suggests that SIT may optimize the brain's ability to process and leverage sensory data for goal-oriented movement.

The rise in age-equivalent scores across all PDMS-2 subtests reflects broad developmental advancement, not just isolated gains in particular skills. The largest improvement occurred in grasping ability, which showed a developmental age increase of over 30 months. This notable progress can likely be attributed to the intervention's strong focus on fine motor manipulation techniques. Such improvements are meaningful in practical terms, given that fine motor skills play a key role in both academic performance and everyday functional tasks.[15]

The rise in Gross Motor Quotient (GMQ), Fine Motor Quotient (FMQ), and Total Motor Quotient (TMQ) shows the program worked well. These combined scores give a fuller picture of motor skills than single test results, making it easier to monitor progress over time. By the end of the study, every participant reached average motor skill levels, showing the program had a real and meaningful effect.

The observed results align with those reported by Karim and Mohammed, who documented marked enhancements in motor abilities among children

with autism spectrum disorder following structured administration of Sensory Integration Therapy (SIT).[16] Comparable findings were reported by Schaaf et al., who found that Ayres Sensory Integration® protocols yield measurable improvements in functional performance and levels of participation.[17] Furthermore, a systematic review conducted by Schoen et al. determined that when SIT is delivered with strict adherence to protocol, it leads to positive outcomes in motor function, adaptive behavior, and overall functional capacity.[18]

Emerging evidence highlights the therapeutic efficacy of sensory-based interventions. A systematic review conducted by Camino-Alarcón et al. indicates that such approaches correlate with enhanced motor skills, postural stability, and functional performance in pediatric populations with autism spectrum disorder (ASD).[19] Additionally, a meta-analysis by Oh et al. reveals that personalized, one-on-one sensory integration therapy (SIT) is associated with marked advancements in developmental outcomes across various neurodevelopmental disorders, particularly ASD.[20]

The physiological basis for these observed improvements is likely attributable to multiple interacting factors. Sensory integration therapy (SIT) facilitates adaptive neurobehavioral responses by delivering organized vestibular, tactile, and proprioceptive stimuli, thereby supporting neural plasticity, optimizing sensory modulation, and refining praxis. These neurophysiological adaptations contribute to more efficient motor performance and greater engagement in functional activities.

Although these results are encouraging, the therapeutic efficacy of sensory integration therapy (SIT) remains a subject of ongoing scientific debate. Systematic reviews have documented inconsistent findings, with such variability largely attributed to methodological shortcomings-including limited sample sizes, non-standardized intervention procedures, and divergent outcome assessment tools.[23] Therefore, while the current evidence contributes to the body of support for SIT, it must be evaluated with due clinical prudence and recognition of these limitations.

Our study had strengths of using the standardized PDMS-2 scale for the assessment of fine and gross motor skills. There was sufficient period of six months for observation and intervention that gives a clear-cut effect of sensory integration therapy effect in autistic children.

There are few limitations of our study that must be recognized. The pre-post study design, small sample size and lack of control group. Furthermore, the absence of extended follow-up prevents determination of the durability of treatment effects, while the lack of blinding in outcome assessment raises the potential for measurement bias. Larger multicenter randomized controlled study and longer follow-up studies required to better evaluate the effects of sensory integration therapy in autistic children. Future research also explore whether improvements in motor skill because of Sensory integration therapy, are associated with better academic performance, social participation, and overall quality of life in children with ASD.[25]

CONCLUSION

In the present study, the sensory integration therapy in the autistic children causes significant improvement in fine and gross motor performance, balance and coordination performance too. Improved motor abilities may lead to better functional abilities of the child regarding play, self-care, and other routine activities. Although the study findings are encouraging, but keeping in mind of the limitations of the study about the sample size and study design. Further large scale studies may help to confirm the role of sensory integration therapy in the improvement of motor skills in the autistic child.

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Author's Contribution

NA : Proposed topic, basic study design, methodology and manuscript writing
HMI: Data collection, statistical analysis and interpretation of results etc
NIQ: Literature review & referencing and quality insurer
SH : Literature review, and manuscript writing
FZ : Literature review, and manuscript writing
MY : Literature review, and manuscript writing

All the authors have approved the final manuscript draft and accept the responsibility of research integrity.